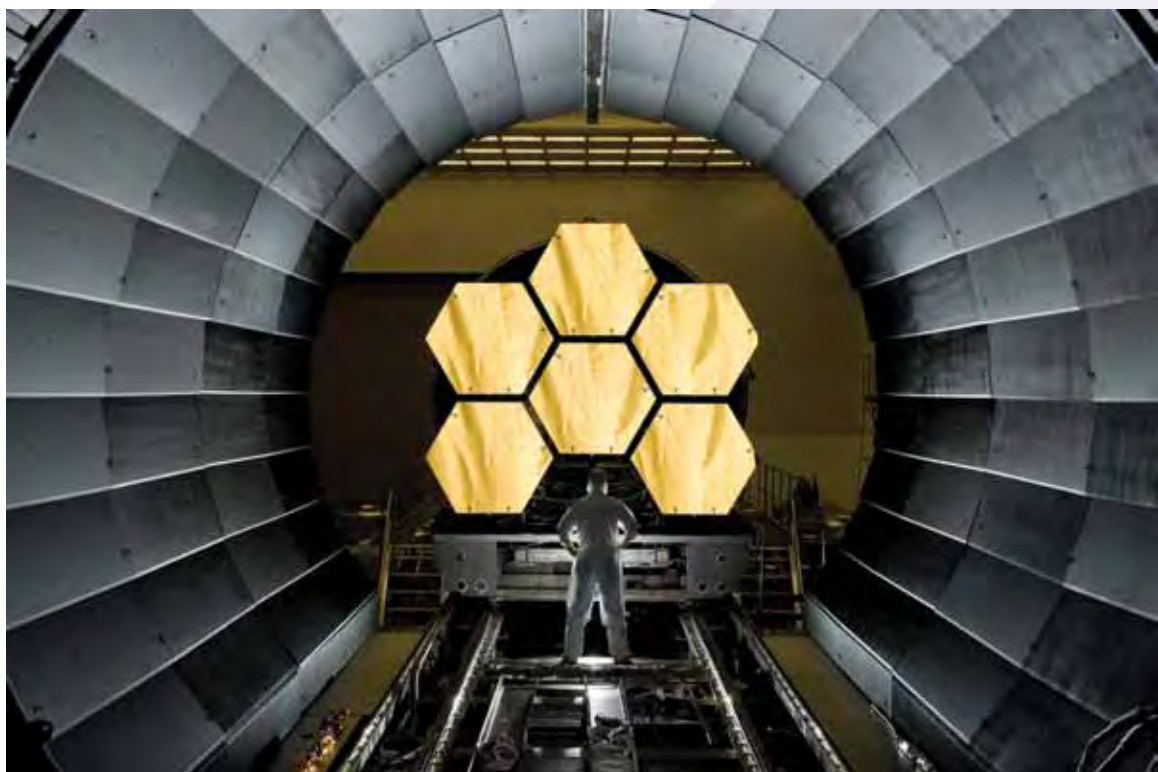


Detailed Performance



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Fiscal Year 2011

Detailed Performance

Measuring NASA's Performance

NASA's [Strategic Plan](#) established a top-level performance framework of strategic goals, multi-year outcomes, and objectives. Every year, NASA releases a performance plan with performance goals and annual performance goals (APGs) that support this performance framework. At the end of the fiscal year, NASA reports on the progress made toward achieving its strategic goals in the Performance and Accountability Report (PAR), which is the compilation of the Agency's annual financial report and annual performance report. This section of the PAR provides detailed information on NASA's performance and is the main content for the annual performance report.

As outlined in the Management Discussion and Analysis section, in FY 2011, NASA rated 108 two- to five-year performance goals, including the five high priority ones, and 149 APGs under a new performance framework and newly revised rating criteria.

Prior to rating these measures, the [FY 2011 Performance Plan](#) was updated to reflect changes due to both Congressional budget action and to correct inaccuracies found in several measures, which were not found prior to the measures' provision in NASA's FY 2012 budget submission to the Congress.

A Reader's Guide to NASA's Detailed Performance Data

This narrative provides a guide to the detailed information on NASA's performance found in this section. The changes to NASA's performance plan are discussed prior to provision of the progress against high priority performance goals (HPPGs) and each strategic goal by outcome. The section culminates with a discussion of the Agency's performance issues and plans for addressing these.

FY 2011 Performance Plan Update

In FY 2011, the Agency updated its performance plan to adjust for funding shifts and inaccuracies found in the measures. These updates are discussed by each individual measure that was either changed or eliminated from the FY 2011 Performance Plan.

NASA's FY 2011 Progress Against the High Priority Performance Goals

NASA's detailed performance data begins with a discussion of NASA's HPPGs in the areas of Earth science, aeronautics, energy management, and space operations. The performance toward this important set of goals is displayed, and information is provided for the reader to understand the rating provided for that HPPG.

Detailed Performance Against NASA's Strategic Goals

NASA's detailed performance data, including how each measure was or was not met, is discussed and displayed by strategic goal. For additional information, reference A New Strategic Plan and Performance Framework section of Management's Discussion and Analysis (see page 15) for background on NASA's performance framework and the link between strategic goals, outcomes, objectives, performance goals, and annual performance goals. All data in this section is provided aligned to that framework.

Strategic Goals

Each strategic goal section introduces the reader to the key programs or offices that support the goal and highlights key milestones completed this year. In addition, the section briefly explains the benefits and risks to achieving the strategic goals. The benefits narrative explains the value of work toward the strategic goal, from gains within the Agency to benefits for academia, the public sector, and government. Risk assessments are a regular part of NASA's review process. NASA outlines and describes the primary risks facing management, as they may affect achievement of that strategic goal and the programs that contribute to it.

Outcomes

Each strategic goal is supported by multiple outcomes, which link the strategic goals to nearer-term targets in the two- to five-year timeframe (performance goals) and for the fiscal year itself (APGs). Each of these sections describes the value of the outcome in reaching the Agency's long-term strategic goal. NASA focuses on a selection of invaluable activities completed in the year. Discussion of these activities demonstrate how NASA met its performance or, in some cases, where it had a challenge.

Performance Measure Descriptions, Ratings, and Trends

Within the outcome section are tables showing the ratings for each performance goal and APG that supports the outcome. Where a performance measure was not met, the description explains what factors contributed to NASA not meeting that targeted performance.

Each performance goal is a multi-year performance target designed to support the overarching strategic goal. HPPGs, which are a sub-set of these measures, are noted with the HPPG designator. While NASA rates the longer-term performance goals annually, the rating takes into account past performance, planned future work, and known risks. For this fiscal year (the first year performance goals have been a part of the performance framework), NASA has not trended performance goals across previous fiscal years.

NASA assigns ratings to the supporting APGs on an annual basis and provides the current ratings along with the previous four years' ratings to show trends in performance. NASA's APGs offer annual snapshots of progress toward a performance goal, with the exception of a sub-set of APGs designated as an efficiency measures, which directly support an outcome and cross multiple performance goals and objectives. These efficiency measures are identified as shown in the sample ratings table in the figure below.

Sample of Annual Performance Goal (Efficiency Measure) Rating and Trending

Uniform and Efficiency Measures					
	FY07	FY08	FY09	FY10	FY 2011
Maintain system execution time during the year-end close process at FY 2010 baseline.	None	8IEM07 Red	9IEM9 Red	10IT12 Green	AMO-11-23 Green

Performance Improvement Plans

This section presents additional detail on trends in the causes of performance shortfalls at NASA and the corrective actions the Agency will take to address the shortfall. In FY 2011, NASA identified categories in which performance trends were seen for measures from both FY 2010 and FY 2011 where targets were not met. The Performance Improvement Plans explain these trends for context and discuss past actions that may have been taken to address the shortfalls. Additionally, they provide a detailed corrective action plan for each FY 2011 APG. See Performance Improvement Plans Introduction on page 155 for more information.

Changes to the FY 2011 Performance Plan

At NASA, changes to an annual performance plan usually are caused by a combination of impacts due to funding shifts and the dynamic nature of research and development. Each budget request contains the annual performance plan that was committed to Congress for the funds requested. When the appropriation differs from the amount requested, or if Congressional direction places a different emphasis on programs than was requested by the Agency, those actions result in an update to the annual performance plan. Additionally, the dynamic nature of research and development can lead to shifting priorities, and the activities that were called out in the annual performance plan may no longer be pursued by NASA.

NASA's policy has been to allow programs to take one of the following actions if they are impacted by Congressional budget action via an appropriations or authorization law:

- Eliminate the performance measure (do not rate the performance measure);
- Change the targeted performance (rate at the new target); or
- Move the measure to the next year's annual performance plan (do not rate until the following year).

In FY 2011, three APGs were significantly impacted as a result of the year-long continuing resolution (CR). However, none of the longer-term performance goals were impacted. The NASA Authorization Act of 2010 was already factored into the FY 2011 Performance Plan prior to inclusion in NASA's FY 2012 Budget Estimates and, therefore, did not impact NASA's targeted performance. The three measures and the changes to the annual performance plan due to the year-long CR are outlined in the table below.

Summary of FY 2011 Annual Performance Goal Changes

Measure	Budget Account/Program	Performance Plan Change
APG 3.2.2.1: ST-11-8: Initiate development of at least one new technology with game changing potential for small satellites.	Space Operations/Space Technology Program	NASA did not release the solicitation and ensuing award for the Franklin Small Satellite System Technologies Program based on receiving funding less than the FY 2011 President's Budget Request levels. NASA does not anticipate pursuing this activity in FY 2012.
APG 3.2.2.1: ST-11-9: Initiate at least one new small satellite mission that will demonstrate game changing or crosscutting technologies in space.	Space Operations/Space Technology Program	The release of the solicitation and ensuing awards for the Edison Small Satellite Demonstration Mission were delayed based on funding less than the FY 2011 President's Budget Request levels.
APG 3.4.1.5 : ST-11-17: Develop an Agency technology portfolio database to track technology investments and create space technology roadmaps that prioritize these investments.	Space Operations/Space Technology Program	This measure has been moved to the FY 2012 Performance Plan. The requisite contract awards could not be made in time to complete the work associated with this measure due to the delay in the funding for the space technology programs as a result of the year-long CR. NASA made progress and successfully conducted an Agency-wide technology tracking system survey, identified existing databases, collected data from existing databases, defined hardware and software requirements, coordinated system development meetings, awarded contracts, and initiated code development. However, since the funds were not available for contract award until late summer, insufficient time was left to complete the development of the new database. NASA expects to complete this work in FY 2012.

NASA generally rates a performance goal or APG White if there is a decision by the Agency to eliminate the program or the work activity during the fiscal year as a result of shifting priorities or other circumstances. In this case, the measure is not eliminated from the annual performance plan, nor is the target reduced. This fiscal year, NASA rated two measures White due to no planned work activities, as explained in the table below.

Summary of FY 2011 Annual Performance Goals Rated White

Measure	Mission Directorate	Rating Justification
APG: EFF AS-11-6: Complete all [Astrophysics] development projects within 110 percent of the cost and schedule baseline.	Science/ Astrophysics	The measure is based on the final development costs once a mission launches. Since there were no planned launches for FY 2011 in Astrophysics, the measure is not applicable to this fiscal year.
APG: EFF HE-11-6: Complete all [Heliophysics] development projects within 110 percent of the cost and schedule baseline.	Science/ Heliophysics	The measure is based on the final development costs once a mission launches. Since there were no planned launches for FY 2011 in Heliophysics, the measure is not applicable to this fiscal year.

NASA found five measures in the FY 2011 Performance Plan that required correction due to inaccuracies that had not been fixed prior to the measures' provision in NASA's FY 2012 budget submission to Congress. These corrections are reflected as a change to the annual performance plan. NASA rated these measures after making the corrections. The table below details the changes NASA made to the original FY 2011 measures that are reflected in this document.

Summary of Corrected FY 2011 Performance Measures

Measure	Budget Account/ Program	Correction Made
PG 2.3.1.2: By 2015 2017, launch at least two [Planetary] missions in support of this outcome.	Science/Planetary	The date was intended to be 2017 to accurately reflect the timeframe for launching the two missions that provide the basis for this measurement.
APG 3.1.1.4: ST-11-4: At least 24 percent of SBIR/STTR Phase II technology projects awarded between 2006-2010 2004-2008 will be infused into NASA programs and projects.	Cross-Agency Support/Innovative Partnership Programs	NASA updated the measure to reflect the correct span of years used as the basis of the rating. This update covers the five-year span needed for the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) phase II work awarded in fiscal years 2004 to 2008 to complete and start into phase III.
APG 3.4.1.3 : ST-11-15: Greater than 35 percent of the SBIR/STTR Phase II technology projects awarded between 2006-2010 2004-2008 will be transferred into commercial products or services.	Cross-Agency Support/Innovative Partnership Programs	NASA updated the measure to reflect the correct span of years used as the basis of the rating. This update covers the five-year span needed for the SBIR/STTR phase II work awarded in fiscal years 2004 to 2008 to complete and start into phase III.
APG 5.4.3.3 : SFS-11-7: Complete Deep Space Station-35 (DSS-35) Pedestal Excavation and Azimuth track at Canberra Deep Space Communications Complex (CDSCC)	Human Exploration & Operations/Space Communication	There was no planned Azimuth track work planned for DSS-35. (In FY 2010, NASA conducted this work on DSS-34.) NASA revised the measure to delete the Azimuth work from the text.
APG 5.4.1.2 : SFS-11-3: Develop processes for crew space transportation partner information sharing between NASA's Launch Services Program (LSP), Exploration Systems Mission Directorate (ESMD), ISS, and other government customers, including but not limited to Department of Defense (DoD).	Human Exploration & Operations/Launch Services	The reference to crew space transportation partner information sharing that would include other U.S. government agencies was incorrect, since none beyond NASA have crewed space flight. NASA's Launch Services Program partners with other government agencies on space transportation, in general.

Additionally, NASA made a revision to the high priority performance goal (HPPG) for Earth science research, from the version provided in the FY 2011 Performance Plan, within NASA's FY 2012 Congressional Justification. This revision was necessitated make the measure consistent with the goal statement as provided on [Performance.gov](http://www.nasa.gov/performance), and to assure the same method of measurement. This goal has been rated Red after the revision, reflected below.

Original Measure	Revised Measure
PG 2.1.5.2 (HPPG): Study Earth from space to understand climate change, weather, and human impact on our planet by launching at least two missions by 2015.	PG 2.1.5.2 (HPPG): In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011.

NASA's FY 2011 Progress Toward the High Priority Performance Goals

In FY 2010, NASA developed and began reporting on five high priority performance goals (HPPGs) on a quarterly basis. In accordance with the [GPRA Modernization Act of 2010](#) and a White House initiative for building a high-performing government, NASA's HPPGs represent challenging, near-term targets that the Agency will reach to benefit the American people in the areas of human exploration, Earth science, aeronautics research, and energy management.

FY 2011 High Priority Performance Goal Summary

High Priority Performance Goal	Responsible Organization	Rating
PG 1.1.1.2 (HPPG): Safely fly out the Space Shuttle manifest and retire the fleet.	Human Exploration Operations, Space Shuttle Program	Green
PG 2.1.5.2 (HPPG): In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011. (Rated after revision)	Science Mission Directorate, Earth Science	Red (See the Performance Improvement Plan for more information.)
PG 4.1.2.1 (HPPG): Increase efficiency and throughput of aircraft operations during arrival phase of flight.	Aeronautics Research Mission Directorate, Airspace Systems	Green
PG 5.2.3.2 (HPPG): Conserve valuable natural resources by reducing NASA's energy and water use.	Mission Support Directorate, Environmental Compliance and Restoration	Yellow (See the Performance Improvement Plan for more information.)
PG 5.5.1.1 (HPPG): Establish an independent non-profit (NPO) organization to enhance the utilization of the ISS as a National Laboratory.	Human Exploration Operations, International Space Station	Green

Safely fly out the Space Shuttle manifest and retire the fleet.

After 30 years of space flight, more than 130 missions, and numerous science and technology firsts, NASA completed the [Space Shuttle](#) manifest with the successful return of Shuttle Atlantis on July 21, 2011, after its mission to the [International Space Station \(ISS\)](#). With that last flight, NASA remains on track to complete close-out activities and ultimately the HPPG.

The Space Shuttle has been essential for construction of the ISS, a multi-decade program between the space agencies of Canada, Europe, Japan, and Russia to build an advanced research and development test bed in low Earth orbit. Since 1998, NASA has dedicated 37 Shuttle flights to the assembly, outfitting, and utilization of the ISS. NASA has used an extensive network of people, facilities, capabilities, industry teams, logistics, organizations, and international partners to safely operate the Space Shuttle. NASA will transfer Space Shuttle assets that can be leveraged for use in future exploration programs and preserve key Agency technical capabilities for future use. Capabilities that are no longer needed or are obsolete will be retired. As the final step in the Space Shuttle's journeys, NASA is preparing the orbiters for display at institutions across the country to inspire the next generation of explorers and engineers. NASA has worked with each of the facilities to complete plans to transfer the orbiters throughout 2012.



In the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida, workers lower the cage containing an Approach and Landing Test Assembly (ALTA) pod over the rear of Space Shuttle *Endeavour*. The ALTA pod is being attached to the site once housing the orbital maneuvering system (OMS) pod. NASA is conducting the demonstration test to ensure the Center's equipment will fit into the hangar at the National Air and Space Museum when installing an ALTA pod on Shuttle *Enterprise*. The pod must be reinstalled on a Shuttle for transport on a 747 carrier aircraft. The simulation also tests procedures and timelines necessary to carry out the process. The work is part of the Space Shuttle Program's transition and retirement processing. (Credit: NASA/J. Grossmann)

In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011.

NASA works to gain a deeper scientific understanding of the components of the Earth system, their interactions, and the consequences of its changes for life, including effects on climate, oceans, air quality, water resources, and biodiversity that sustain life and society. NASA's [Earth Science Program](#) conceives, develops, and operates a fleet of sophisticated scientific spacecraft for Earth observation. This fleet, by making complementary key measurements, provides improved understanding of the Earth system. The [NPOESS Preparatory Project \(NPP\)](#) and [Glory](#) missions were the next spacecraft planned to join this fleet.

NPP will extend key climate measurements begun by NASA's [Earth Observing System](#) for the climate research and applications communities. It also will serve as an essential gap-filler, owing to delays in the development and launch of the [National Polar-orbiting Operational Environmental Satellite System](#), or NPOESS, for the Nation's civil and military operational weather prediction efforts. Throughout FY 2011, NASA made extraordinary progress on meeting the development milestones for NPP, including preparation of the ground-based systems required to send commands to, and receive and process data from, the NPP spacecraft and instruments. The mission launched successfully on October 28, 2011, from Vandenberg Air Force Base in California.



On September 15, 2011, technicians perform final testing on NASA's NPP satellite in a clean room at Vandenberg Air Force Base in California. (Credit: Ball Aerospace)

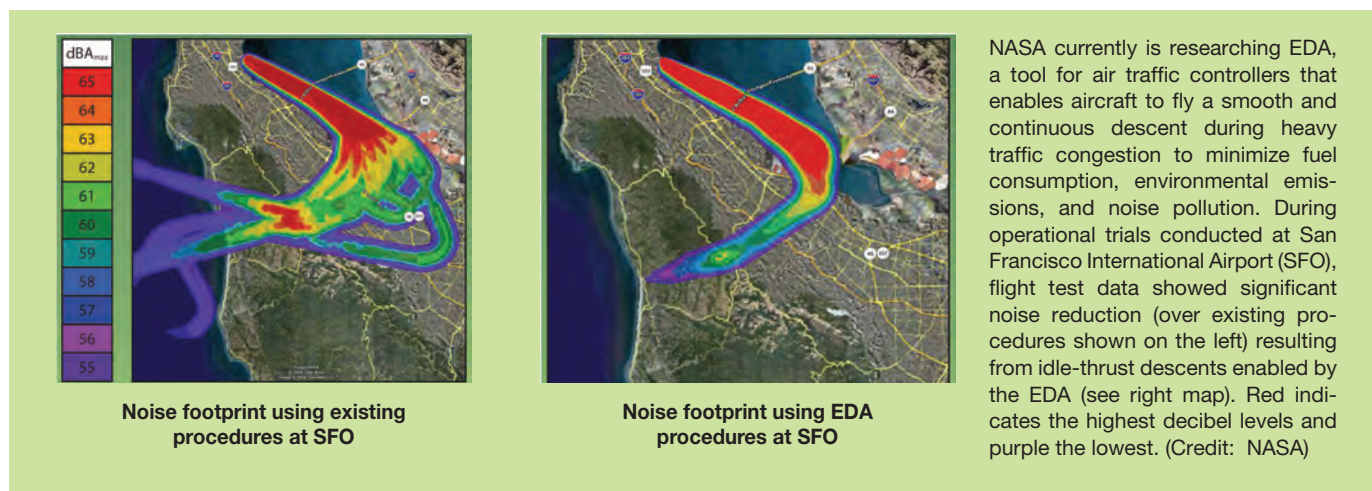
The Glory mission was designed to measure, for the first time, aerosol size, quantity, physical properties, and shape, helping researchers distinguish the relative influences of natural and human-caused aerosols on our global climate. On March 4, 2011, Glory launched from Vandenberg Air Force Base in California. The countdown and launch went smoothly until the point at which the fairing, the protective shell atop the rocket, was to separate from the vehicle. Telemetry data has indicated the fairing did not separate as expected about three minutes after launch, and the Glory spacecraft did not reach orbit.

With the unfortunate loss of the Glory mission, NASA did not meet all the milestones associated with this high priority performance goal. In response to the loss, NASA has created a Mishap Investigation Board to evaluate the cause of the failure and will use the results to determine the next steps for providing reliable mid-sized launch services for NASA science missions. The [Science Mission Directorate](#) is evaluating the loss of the mission on the long-term science objectives, and discussing the options available to keep on-track toward this performance goal. The relative priority for replacing the Glory measurements will be considered in the context of the Earth Science portfolio and all of its objectives, in the coming year.

Research and develop new technologies to increase the flexibility and efficiency of the Nation's air traffic system.

Current air traffic control operations require an air traffic controller to generate and provide clearances manually (that include path and speeds) so that aircraft can arrive at an established point on a route, and time-regulate entry into an airport's terminal area, at a scheduled time during the arrival phase of flight. The manual process often results in inefficient paths for an aircraft's flight and descent (particularly during higher traffic density operations), restricting the number of aircraft that can be processed for arrival operations, as well as increased noise and fuel consumption.

The [En Route Descent Advisor \(EDA\)](#) is a tool that proposes to the air traffic controller the speed and path changes that will allow an efficient arrival profile. EDA monitors many aircraft simultaneously, maximizing throughput by ensuring that each aircraft meets its scheduled time for arrival, while avoiding flight path conflicts between aircraft. EDA's innovation includes reducing flight time, fuel consumption, noise, and emissions, thus resulting in more environmentally friendly en route and terminal operations.



To support the effort, NASA will provide to the Federal Aviation Administration (FAA) the demonstration results from field tests of the EDA tool. In FY 2011, NASA made great progress toward this high priority performance goal. The Airspace Systems Program conducted four human-in-the-loop simulations using the EDA tool. The final simulation conducted at the end of September 2011 was designed to document the benefits for use of the tool if widely used in the national airspace system. NASA will use these results to develop the technology transition document required by the FAA by next year, which is the next step for moving use of the technology into use in real airport operations.

Conserve valuable natural resources by reducing NASA's energy and water use.

NASA Centers have been steadily working to reduce energy consumption and create innovative practices for energy sustainability since 2005. In the past four years, even as consumption was reduced, the unit cost of energy has increased dramatically, without offsetting budget increases. The Agency is working aggressively to implement alternative and innovative energy practices and resources to supply and to conserve energy in the operation of its facilities. NASA is seeking improvement in three major areas:

- For facility energy use, the target is 30 percent reduction in energy intensity btu/gsf (or energy per gross square foot) by the end of 2015 (from a 2003 baseline, reduce energy three percent per year for 2006–2015).
- For fleet vehicle energy use, the target is 30 percent reduction in fleet total consumption of petroleum products by the end of 2020 (two percent per year from a 2005 baseline).
- For potable water use, the target is 26 percent reduction in water intensity gal/gsf (or gallons per gross square foot) by the end of 2020 (two percent per year from a 2007 baseline).

Efforts in FY 2011 that support these goals included submitting the 2011 NASA Strategic Sustainability Performance Plan to the Office of Management and Budget, investing \$48 million in energy related construction/recapitalization projects, and establishing Solar Assisted Electric Vehicle Charging Stations.

Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA expects to exceed its targets on the measures related to water use and fleet management, but fall short on the energy intensity goal, against the annual target set to meet Executive Order 13423. In FY 2011, NASA reduced energy intensity by an estimated one percent (three percent was the target), for an eight percent reduction from 2003 baseline. The rating seen for this high priority performance goal reflects not fully meeting the annual target.

To continue efforts to reduce energy consumption and improve NASA's aging infrastructure, the Agency designs and constructs new buildings to the minimum Leadership in Energy and Environmental Design Silver standard. NASA is increasing energy savings performance contracts and utility energy service contracts at various Centers and created a position at Headquarters to support the Centers with implementation and execution of these complex projects. Additionally, NASA performed an Agency survey for renewable energy project opportunities and is evaluating the final report for project identification. Projects to reduce energy intensity will be initiated per available funds. Lastly, the Agency has applied for in-kind enhanced-use leasing authority with the FY 2012 budget request to implement large renewable energy projects that could significantly reduce energy intensity.

Establish an independent organization to enhance the utilization of the International Space Station as a National Laboratory.

The ISS provides a multidisciplinary, cutting edge, unique research platform to pursue microgravity and engineering research and technology development test bed applications. The ISS is a critical step in developing, testing, and validating the next generation of space technologies and operational processes needed to explore beyond low Earth orbit.

Providing access to this resource to researchers outside of traditional NASA program mechanisms, as made possible by an independent non-profit organization (NPO), will encourage and enhance research and innovations to address other national priorities or concerns. Potential discoveries, particularly in the area of human health or energy technologies, could benefit future NASA missions, as well as enhance life on Earth.

On August 31, 2011, NASA signed a Cooperative Agreement with the Center for the Advancement of Science in Space (CASIS) as the independent NPO to develop and manage the U.S. portion of the ISS to be operated as a National Laboratory. With the signing of this agreement, NASA has successfully completed a significant milestone in this fiscal year and achieved the high priority performance goal.

Located at the Space Life Sciences Laboratory near the Kennedy Space Center, CASIS will be a single point of contact for U.S. (non-NASA) researchers. In addition, CASIS will be responsible for maximizing the value of the ISS by stimulating use of the ISS as a National Laboratory and developing and managing a diversified research and development portfolio for conducting basic and applied research.

This photo, taken during a July 12, 2011, spacewalk, shows the Materials on International Space Station Experiment (MISSE)-8 attached to the outside of the ISS. The experiment package is evaluating the effects of atomic oxygen, ultraviolet, direct sunlight, radiation, and extremes of heat and cold on materials and computing elements. The results of this experiment will help researchers develop new materials and computing elements that can better withstand the rigors of space environments. CASIS will have the responsibility of using the ISS' unique research facilities, including its unpressurized, exterior platforms, to develop its potential as a National Laboratory. (Credit: NASA)



Strategic Goal 1

Extend and sustain human activities across the solar system.

Humans are driven to explore the unknown, discover new worlds, push the boundaries of scientific and technical limits, and then push further. For over 50 years NASA has been tasked with developing the capabilities that will support the country's long-term human space flight and exploration efforts. The Agency's operations have increased in complexity, and crewed space journeys have increased in duration. With the help of domestic and international partners, NASA has embarked on a steady progression of activities and milestones that has prepared the Agency for the more difficult challenges ahead—expanding permanent human presence beyond low Earth orbit. NASA will pursue this goal through strategic investments and partnerships to drive advances in science and technology. To be successful, NASA will need equal and full participation from international partners and the commercial sector, including mission-enabling contributions, support capabilities, and technologies. NASA's human spaceflight programs are responsible for keeping astronauts healthy, safe, and productive through the Agency's work in human health, life support systems and habitation, and numerous technologies for exploration in space or on another planet. Looking toward the future, NASA is developing a new Space Launch System, Orion Multi-Purpose Crew Vehicle, and ground systems to support exploration activities.

Benefits

NASA and its international partners have sustained a continuous human presence in low Earth orbit for over a decade, transcending individual nationalism to live, work, and make discoveries in space that benefit everyone. Mission by mission, the men and women who fly aboard the International Space Station (ISS) are developing capabilities that will enable NASA to expand human space exploration across the solar system, and performing multidisciplinary, cutting-edge research that supports a broad array of biological and physical research objectives. Today, NASA is leveraging the capabilities of the commercial sector to enable robotic and human space flight as we partner with industry to develop the advanced technologies for exploration. These investments act as an economic stimulus across a broad spectrum of industries.

Expedition 27 crewmember Paolo Nespoli took this image of ISS and the docked Space Shuttle *Endeavour* (STS-134) from the Soyuz TMA-20 following its undocking on May 23, 2011. (Credit: NASA)



Risks to Achieving Strategic Goal 1

Advanced Technology Development. Innovative and affordable technologies are fundamental building blocks required to safely send humans to ISS and beyond low Earth orbit. They must be pursued, developed, and matured over many years. These long timelines pose a challenge as national priorities change and NASA shifts program focus. Currently, the human space flight programs are partnering with the Office of the Chief Technologist to enable the rapid development and testing of a broad set of prototype systems to enable future human missions. These prototype systems can be used as building blocks to construct a variety of mission systems for exploration of the Moon, near Earth asteroids, and Mars, and to provide the flexibility to adapt to new objectives in the future.

Availability of Commercial Cargo and Crew Services. A key factor in sustaining and operating ISS is the ability to provide crew transportation and ensure cargo resupply now that the Space Shuttle fleet is retired. NASA will continue to use the vehicles of the international partners for crew transportation, rescue, and cargo resupply as we develop additional U.S. provided capabilities.

Affordability and Sustainability. Exploration beyond low Earth orbit will span decades. NASA's budget requests are intended to maintain a sustainable exploration strategy to secure the long-term stability of these programs that will extend human presence into the solar system. NASA has developed an architecture that is affordable and sustainable over a long budget horizon through programs that accommodate external changes by employing innovative acquisition approaches and industry best practices. NASA will continue to focus on affordability and performance factors, and collaborate with interagency and international partners to ensure the safe execution of exploration missions beyond low Earth orbit.



The Orion Multi-Purpose Crew Vehicle makes a big splash as it hits the water during its third water landing test conducted at the Hydro Impact Basin located at NASA Langley Research Center. This test represented the worst-case scenario for landing. The prediction had a 50 percent chance of the test article getting inverted. During the tests, the Orion Project Team collected valuable data regarding Crew Vehicle stability. They also obtained invaluable experience in uprighting the test article. (Credit: NASA/S. Smith)

Outcome 1.1

Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.

The ISS is a major stepping stone in achieving NASA's exploration goals across the solar system. It provides a space-based research and development laboratory to safely perform multidisciplinary, cutting-edge research. The continuously crewed laboratory—the Nation's newest National Laboratory—enables the ongoing evolution of research and technology objectives and ensures that the benefits of this multinational investment can be realized.

Under the auspices of a non-profit management organization, NASA will continue to make the ISS available as a national resource to promote opportunities for advancing basic and applied research in science and technology to other U.S. government agencies, university-based scientists and engineers, and private firms. The National Laboratory management entity will be responsible for stimulating, developing, and managing a diversified research and development portfolio using the ISS to address U.S. needs.

The ISS Program completed several milestones during FY 2011, including final construction of the ISS vehicle, sustaining operations on-board, and accomplishing all on-orbit research objectives.

Completing construction of the ISS

For the ISS, FY 2011 marked the final assembly of the major structure.

Discovery (STS-133) delivered the Italian-built Permanent Multipurpose Module (PMM). Named Leonardo, NASA used the module to ferry supplies, equipment, experiments and other cargo to and from ISS via the Space Shuttle's payload bay. Leonardo had visited the station seven times before as a cargo carrier before being refurbished to serve as a permanent 2,472 cubic-foot addition to the orbiting laboratory, providing more space and accommodations for research. Among the 6,000 pounds of Leonardo cargo was Robonaut 2, a human upper torso-like robot that could be a precursor of devices to help during spacewalks. During Discovery's almost nine days at the ISS, the Shuttle crew performed two spacewalks for maintenance work and installation of new components. The ISS also received two more Express Logistics Carriers (ELCs) on STS-133 and STS-134. These unpressurized platforms attached to the exterior of the ISS that can be used for research. Both the PMM and the ELCs will provide greater space and accommodations for research to be performed on ISS.

Sustaining operations on ISS

During the fiscal year, the ISS was visited by 13 vehicles, including the final Shuttle mission, STS-135, which launched in July 2011. In all, the vehicles delivered 143,000 pounds (65,000 kilograms) of fuel, research equipment, spare hardware, and supplies, leaving the ISS well supplied and ready to support utilization activities, as well as the first commercial resupply missions.

In August, the Russian Progress 44P, loaded with fuel and supplies bound for the ISS, failed to reach orbit due to a launch vehicle failure. The ultimate impact of the 44P loss is not yet completely quantified,



European Space Agency astronaut Paolo Nespoli, Expedition 27 flight engineer, works with the Light Microscopy Module (LMM) in the Destiny laboratory on April 21, 2011. LMM is designed to research colloidal structures, a mixture in which one substance is divided into minute particles (called colloidal particles) and dispersed throughout a second substance. (Credit: NASA)

but the resupply visits from the other vehicles left the ISS well prepared for the next fiscal year. The ISS was reduced to three crew members with the return of three Expedition 28 crew members on Soyuz 26S. This planned return was part of the standard six crew rotation plan, which always includes a temporary period of three crew operations. Crewed Soyuz flights will resume with the launch of 28 Soyuz on November 14, 2011, restoring the ISS back to a full crew of six.

Conducting research aboard the ISS

NASA's research goals for the ISS are driven by the [NASA Authorization Act of 2010](#) and are focused on four areas: human health and exploration, technology testing for enabling future exploration, basic life and physical sciences, and earth and space science. During FY 2011, the ISS Program provided 100 percent of all on-orbit resources needed to support the ISS research objectives including power, data, logistics, crew time, and accommodations.

Human health research and applications

In 2011, NASA's [Human Research Program \(HRP\)](#) made extensive use of the ISS to perform research on maintaining human health and performance during and after long-duration space flight. HRP flew 11 major medical experiments to evaluate the immune system and other human health areas to make exploration missions healthier, safer, and more productive. HRP also added new ISS biomedical capabilities, including the second-generation ultrasound for medical imaging, the Urine Monitoring System, and the jointly developed [European Space Agency \(ESA\)](#)–NASA Muscle Atrophy Research and Exercise System. Additionally, HRP developed programmable lighting to aid in astronaut adaptation to the work, rest, and sleep cycle while living on the ISS.

During the fiscal year, the program delivered significant research products that will help take human space explorers far beyond low Earth orbit, such as an updated space radiation cancer risk model that predicts the lifetime cancer health risk from exposure to deep space radiation—a vital tool in planning safe exploration missions.

Under the leadership of HRP, NASA collaborated with ESA in January 2011 to develop and deploy a highly successful international outreach program called “[Mission X](#),” which brought together 14 space agencies and various partner institutions to work together to address health and fitness education for young people around the globe.

NASA lists and summarizes the experiments conducted aboard the ISS on the program's Web site at http://www.nasa.gov/mission_pages/station/research/experiments/experiments_by_expedition.html. See expeditions 25/26 (September 2010 through March 2011) and expeditions 27/28 (March 2011 through September 2011) for experiments spanning FY 2011.

The biological and physical sciences

NASA's biological and physical sciences conducts openly solicited, peer-reviewed research to understand the fundamental laws of nature. This research produces foundational knowledge necessary to develop systems, like life support and radiation shielding, for the next generation of spacecraft and to reduce the risk for humans traveling in space.

The last two missions of the Space Shuttle were instrumental in enabling this research. Eight space flight experiments were conducted to characterize various effects of spaceflight on the mammalian immune system, effects of an experimental bone countermeasure on muscle and bone, and new means to reduce biofilm formation, and plant studies to characterize mechanisms of plant signaling that can help improve future strategies for plant growth in space. In addition, 43 post-flight Bio-specimen Sharing projects studied the effects of space flight on virtually all the mammalian tissue—ranging from the brain to the reproductive system—after return to Earth. The knowledge gained by these experiments have furthered researchers' understanding of how space affects living systems and also will have applications for Earth.

In accordance with the NASA Science Plan, NASA is making significant progress in the developing ISS hardware to support the flight of rodents and large plants on ISS. Finally, NASA completed and published the [Space Biology Science Plan](#) for the next decade, 2010 through 2020.

In FY 2011, NASA completed pioneering research on polymeric liquids aboard the ISS. This project, in planning since the mid-1990s, uses microgravity to examine the behavior of polymeric liquids, which include saliva, adhesives, and inks. The results of the ISS experiment will help scientists build better models of polymeric liquids, leading to improvements across a range of technologies that use polymeric liquids. [Watch a video](#) of the principle investigator explaining his experiment and demonstrating some of the interesting mechanical properties of saliva.

Other important research in completed in 2011 included the Flame Extinguishment Experiment. This research, led by internationally prominent experts in combustion research, has provided benchmark data on a fundamental element of many combustion technologies, the burning drop of liquid fuel. The results of these space experiments will contribute to models of spray combustion supporting the development of more effective fire suppression technologies in space vehicles and the design of improved combustors with greater fuel efficiency and lower emissions characteristics in systems that rely on spray combustion like diesel engines.

Education from space

ISS educational activities have had a positive impact on thousands of students by involving them in ISS research, and by using the station to teach them the science and engineering that are behind space exploration. Below are some examples of ISS educational activities conducted during the fiscal year:

ISS educational activities—focusing on the K–12 classroom and designed to encourage learning and interest in science, technology, engineering, and mathematics (STEM) education—examined weaving characteristics of spiders, movement behaviors of fruit flies, and directional plant growth in response to light sources.

The Kids In Micro-G hands-on design challenge was won by two fifth grade girls from San Diego, California, who designed a study called “Attracting Water Drops” to look at static attraction in microgravity. The purpose of the challenge was to give students a hands-on opportunity to design an experiment or simple demonstration that could be performed both in the classroom and by astronauts aboard the ISS.

The Commercial Generic Bioprocessing Apparatus Science Insert experiments are educational ISS payloads designed to interest K–12 students in STEM by providing the opportunity for these students to participate in near real-time research conducted aboard the ISS. The project is managed by BioServe Technologies, in partnership with NASA, Orions Quest, Adventures of the Agronauts, Baylor College of Medicine’s Center for Educational Outreach, Monarch Watch at University of Kansas, and the Denver Museum of Nature and Science.

Outcome 1.1					
Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.					
FY 2011 Performance Goal					FY 2011
Maintain capability for six on-orbit crew members.					1.1.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
In concert with the International Partners, maintain a continuous crew presence on the ISS by coordinating and managing resources, logistics, systems, and operational procedures.	7ISS5 Green	8ISS06 Green	9ISS6 Green	10ISS07 Green	ISS-11-1 Green
FY 2011 Performance Goal					FY 2011
HPPG: Safely fly out the Space Shuttle manifest and retire fleet.					1.1.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Release major Space Shuttle operations facilities at Kennedy Space Center for future institutional and programmatic use.	None	None	None	10SSP04 Green	SSP-11-1 Green
FY 2011 Performance Goal					FY 2011
Provide cargo and crew transportation to support on-orbit crew members and utilization.					1.1.1.3 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Fly the ISS elements, spares, logistics, and utilization hardware as agreed to by the International Partners to the ISS transportation plan.	7ISS3 Green	8ISS03 Green	9ISS3 Green	10ISS03 Yellow	ISS-11-2 Green
FY 2011 Performance Goal					FY 2011
Maintain and operate a safe and functional ISS.					1.1.1.4 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Provide 100 percent of planned on-orbit resources (including power, data, crew time, logistics, and accommodations) needed to support research.	None	8ISS04 Green	9ISS4 Yellow	10ISS04 Green	ISS-11-3 Green
Achieve zero Type-A (damage to property at least \$1 million or death) or Type-B (damage to property at least \$250 thousand or permanent disability or hospitalization of three or more persons) mishaps.	None	None	None	10ISS05 Green	ISS-11-4 Green
FY 2011 Performance Goal					FY 2011
Advance knowledge of long-duration human space flight by establishing agreements with organizations to enable full utilization of the ISS.					1.1.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Accomplish a minimum of 90 percent of the on-orbit research objectives as established one month prior to a given increment, as sponsored by NASA, baselined for FY 2011.	7ISS2 Green	8ISS02 Green	9ISS2 Green	10ISS02 Green	ISS-11-5 Green
FY 2011 Performance Goal					FY 2011
Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.					1.1.2.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Develop at least two life sciences flight payloads for ISS or Free Flyer platforms.	None	8AC02 Green	9AC3 Green	10AC03 Green	ERD-11-1 Green
Deliver at least five physical sciences payloads for launch to the ISS.	None	8AC01 Green	9AC1 Green	10AC01 Green	ERD-11-2 Green
Conduct at least five experiments in combustion, fluids or materials sciences on the ISS.	None	None	9AC2 Green	10AC02 Green	ERD-11-3 Green

Outcome 1.2

Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.

Commercial space transportation is a vital component to the future of human space exploration. As NASA charts a new course to send humans deeper into space than ever before, it also is stimulating efforts within the private sector to develop and operate safe, reliable, and affordable commercial space transportation systems. Once the capabilities are matured and available to the government and other customers, NASA could purchase commercial services to transport crew and cargo to the International Space Station (ISS) and low Earth orbit.

NASA's Commercial Orbital Transportation Services (COTS) is an investment designed to spur development of cost-effective, U.S. commercial space transportation systems that could eventually be used to carry cargo and crew to the ISS. COTS currently funds Space Act Agreements with two partners, Space Exploration Technologies Corporation (SpaceX) and Orbital Sciences Corporation (Orbital) for the development and demonstration of cargo transportation capabilities. COTS awarded a funded Space Act Agreement to SpaceX during the initial competition in 2006 and to Orbital during the second round of competition in 2008.

During FY 2011, NASA commercial partners made progress towards accomplishing their final demonstration missions, which will include proximity operations and berthing with ISS.

SpaceX makes history with its successful demonstration mission

On December 8, 2010, SpaceX completed its first COTS demonstration mission. During this demonstration mission, SpaceX launched its Dragon spacecraft into orbit on its Falcon 9 launch vehicle. The Dragon completed two orbits of Earth, and became the first commercial spacecraft in history to reenter the atmosphere from low Earth orbit and splash down. Currently, the Falcon 9 launch vehicle and Dragon spacecraft are at the SpaceX launch facility at Cape Canaveral in Florida in preparation for the next COTS demonstration mission.

NASA's investments with its commercial partners are beginning to bear fruit in other ways. SpaceX reports having 30 missions on its current manifest, many of these being foreign launch customers. The COTS investment is helping the United States become more competitive in the global launch marketplace and increase its percentage of the launch market. The Nation now stands at the beginning an era of providing the best global value to both government and commercial launch customers.

Orbital completes milestones in preparation for maiden launch vehicle flight

Orbital completed several milestones, preparing the company for its first Taurus II launch vehicle maiden flight and final demonstration mission. Orbital completed a cargo demonstration using a sample manifest that included physical stowage of cargo simulators in their pressurized cargo module. Orbital began launch vehicle engine acceptance testing



SpaceX's Falcon 9 launches on December 9, 2010, from Cape Canaveral Air Force Station, next to Kennedy Space Flight Center in Florida. (Credit: SpaceX)

Orbital's Cygnus spacecraft Service Module is shown here during its development. (Credit: Orbital Sciences Corporation)



and delivered launch vehicle and spacecraft flight hardware to NASA's Wallops Flight Facility. This spacecraft flight hardware included the maiden flight launch vehicle and flight Pressurized Cargo Module (PCM) in preparation for the demonstration mission next year.

NASA awards second round of commercial crew development awards

To further stimulate efforts within the private sector for the development and demonstration of safe, reliable, and cost-effective space transportation capabilities, NASA awarded approximately \$270 million to four commercial companies in April 2011 and approximately \$46 million in September 2011 in optional milestones.

This investment by NASA continues and expands the 2009 Commercial Crew Development (CCDev) initiative where NASA used American Recovery and Reinvestment Act funds to develop and demonstrate human spaceflight capabilities. Through this new effort, CCDev2, NASA's commercial partners will further advance commercial crew space transportation system concepts, maturing the design and development of system elements such as launch vehicles and spacecraft. These investments will spur economic growth as capabilities for new cost effective space markets are created. NASA and the nation will benefit from a reduced gap in U.S. human spaceflight capability. (Read more about the CCDev2 awards.)

Setting requirements for commercial services

During the fiscal year, NASA has been developing the acquisition strategy and long term planning for investment in end-to-end commercial crew transportation capabilities. In December 2010, NASA released the Commercial Crew Transportation System requirements for NASA low Earth orbit missions, which provides a consolidated set of requirements, standards, and processes that will be applied to the certification of a specific commercial crew transportation system for low Earth orbit missions.

NASA developed a series of documentation to communicate roles and responsibilities, technical management processes supporting certification, crew transportation system and ISS services requirements, ISS interface requirements, and the application of technical and operations standards for potential commercial partners. Over the year, these documents have been reviewed within NASA and by industry. NASA's overarching strategy for the development of these documents is to ensure the requirements meet NASA safety and performance standards, yet is not overly prescriptive and allows commercial industry maximum flexibility to develop safe, reliable, and cost effective human space transportation systems.

Outcome 1.2					
Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.					
FY 2011 Performance Goal					FY 2011
Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.					1.2.1.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Conduct a minimum of one commercial cargo demonstration flight of new cargo transportation systems.	None	None	None	10CS08 Yellow	CS-11-1 Green
Conduct a minimum of one commercial cargo demonstration flight of proximity operations with ISS.	None	8CS08 Yellow	9CS9 Yellow	10CS07 Yellow	CS-11-2 Yellow
Why NASA rated APG CS-11-2 Yellow: This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones. (See page 166 for the Performance Improvement Plan.)					
Conduct a minimum of one safe berthing of commercial cargo transportation systems with the ISS.	None	None	None	10CS08 Yellow	CS-11-3 Yellow
Why NASA rated APG CS-11-3 Yellow: This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones. (See page 166 for the Performance Improvement Plan.)					
Release announcement for the development of commercial crew transportation systems (CCDev2).	None	None	None	None	CS-11-4 Green
FY 2011 Performance Goal					FY 2011
Develop and document evaluation and certification processes for an integrated commercial crew transportation system.					1.2.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop NASA processes and requirements required to ensure crew safety to and from the ISS and other NASA and low Earth orbit destinations.	None	None	None	None	CS-11-5 Green

Outcome 1.3

Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.

Exploration beyond low Earth orbit will span decades, with the first step in embarking on this long and challenging journey involving the development of solid groundwork to ensure a successful endeavor. Experienced personnel from across the Agency are building a set of architectures, or mission frameworks, for multiple destinations in the solar system. These architectures include all aspects of mission performance—technologies, partnerships, safety, risk, schedule, and stakeholder priorities—that define the knowledge, capabilities, and infrastructure necessary to support human space exploration.

Team begins building a NASA architecture

In FY 2011, NASA formed the Human Architecture Team (HAT) to further develop mission architectures that include all aspects of mission performance. HAT met weekly to share information across the Centers and focus Design Reference Mission (DRM) studies toward evolving technologies and launch vehicle architectures. HAT created 10 DRMs that capture national and international priorities for evaluation by Agency stakeholders.

Additionally, HAT provided technical support to the development and release of the Global Exploration Roadmap, an international collaboration to collect, organize and align international space agencies' high level objectives for future space exploration. The lead organization, International Space Exploration Coordination Group, released the Global Exploration Roadmap on September 23, 2011. The report can be found at <http://www.nasa.gov/exploration/about/isecg/>.



SLS sits on the launch pad in this artist's concept. The launch vehicle will be able to carry the Orion Multi-Purpose Crew Vehicle, as well as cargo and equipment to Earth orbit and beyond. (Credit: NASA)

The vehicles and systems

NASA announces design for new deep space exploration system

On September 14, 2011, NASA announced that it was ready to move forward with the development of the Space Launch System (SLS), an advanced heavy-lift rocket to support missions beyond low Earth orbit. The NASA Authorization Act of 2010 directed NASA to develop the SLS, and significant work was completed in FY 2011 to refine the overall vehicle architecture while continuing hardware testing. Based on an intensive series of requirements and alternatives analysis reviews, NASA chose an evolvable architecture based on hardware used on Space Shuttle and in development under the Constellation Program, including Space Shuttle Main Engines (RS-25d), Core and Upper Stage designs based on existing Space Shuttle External Tank diameters, the J-2X engine for the Upper Stage, and five-segment solid rocket boosters for the initial SLS test flights.

Representative of the extensive testing and hardware development in FY 2011 was the first set of hot fire tests of a complete J-2X engine at the Stennis Space Center and a test of a five-segment booster in Utah. NASA has shared its vision of the SLS development through the release of procurement documents at an Industry Day in Huntsville, AL on September 29, 2011.



Technicians position microphones around the Orion MPCV and launch abort system test articles in preparation for the second round of acoustic tests. More than 600 instruments, 500 accelerometers and 100 microphones were placed throughout the Orion crew module/launch abort system stack to test critical components of the spacecraft such as avionics, propulsion and crew life support. (Credit: Lockheed Martin)

NASA continues work on Orion

On May 24, 2011, NASA announced that the Multi-Purpose Crew Vehicle (MPCV), also part of the NASA Authorization Act of 2010, will be based on the Orion Crew Exploration Vehicle design. The Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during space travel, and provide safe reentry.

NASA began a campaign of Orion landing tests at the Langley Research Center's Hydro-Impact Basin, splash testing the "boilerplate" test vehicle to investigate different kinds of water landing scenarios. The Orion also completed construction of its Ground Test Article (GTA) vehicle, the next higher-fidelity vehicle beyond the "boilerplate." The GTA was brought to the Orion Denver facility to begin the first campaign of vibro-acoustic testing to better understand the forces that will be transmitted to the inside of the Orion during a launch abort. NASA also flew a test of rendezvous and docking technology, known as STORM, on the second to last flight of the Space Shuttle, STS-134, potentially supporting future docking operations.

The human element

Defining capabilities and conducting research

NASA defined and baselined the top-level requirements in the Human Exploration Capabilities Requirements Document and a draft program plan is in review. To this end, NASA continues to reduce the risk for human space exploration. The highest risks to human health and performance are investigated and mitigated by providing essential countermeasures and technologies for human space exploration. Risks include physiological effects from radiation, reduced and micro-gravity, and terrestrial environments, as well as unique challenges in medical support, human factors, and behavioral health support. NASA utilizes an Integrated Research Plan (IRP) to identify the approach and research activities planned to address these risks, whether on the ISS, or in a ground-based laboratory, on Earth. The Human Research Roadmap is the web-based tool for communicating the IRP content (see <http://humanresearchroadmap.nasa.gov/>).

NASA released two NASA Research Announcements in FY 2011. One released on January 27, Ground-Based Studies in Space Radiobiology, solicited research in space radiation biology to take place at the NASA Space Radiation Laboratory at Brookhaven National Laboratory, New York. Another released on August 23, the Joint NASA and National Space Biomedical Research Institute's Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions, solicited innovative research addressing risks identified in NASA's human research roadmap.

The Space Studies Board of the National Academies is conducting an evaluation of NASA's space radiation cancer risk model to identify any gaps in NASA's current research strategy. There are still uncertainties about estimating the health risks of exposure to galactic cosmic rays. As a result, NASA limits astronaut exposure to an amount that could make future long-duration space exploration difficult. On August 1, NASA provided the review committee a copy of the NASA report, "Space Radiation Cancer Risk Projections and Uncertainties—2010," which defines NASA's models for different conditions and individuals. With delivery of this report, NASA's active role in the evaluation was complete. The Space Studies Board committee has completed its evaluation and the final report should be available in early FY 2012.

Outcome 1.3					
Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.					
FY 2011 Performance Goal					FY 2011
Complete design reviews for Space Launch System (SLS).					1.3.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop top level Agency requirements and draft Program Plan for Space Launch System (SLS).	None	None	None	None	HEC-11-1 Green
FY 2011 Performance Goal					FY 2011
Complete design reviews for Multi-purpose Crew Vehicle (MPCV).					1.3.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop top level Agency requirements and Program Plan for Multi-Purpose Crew Vehicle (MPCV).	None	None	None	None	HEC-11-2 Green
FY 2011 Performance Goal					FY 2011
Develop technologies that enable biomedical research and mitigate space human health risks associated with human space exploration missions.					1.3.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop and release two NASA Research Announcements that solicit from the external biomedical research community the highest quality proposals to mitigate space human health risks.	None	None	None	None	ERD-11-4
FY 2011 Performance Goal					FY 2011
Perform research to ensure that future human crews are protected from the deleterious effects of space radiation.					1.3.2.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the independent assessment of the updated NASA Space Radiation Cancer Risk Model used to project the cancer risk for current ISS crews and future exploration missions.	None	None	None	10AC05 Green	ERD-11-5 Green
FY 2011 Performance Goal					FY 2011
Develop exploration medical capabilities for long-duration space missions.					1.3.2.3 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop and begin implementation of a research plan to address a recently discovered risk to crewmembers involving microgravity-induced visual alterations.	None	None	9AC7 Yellow	10AC06 Green	ERD-11-6 Green
			9AC4 Green	10AC07 Green	
			9AC5 Yellow	10AC07 Green	

Strategic Goal 2

Expand scientific understanding of the Earth and the universe in which we live.

Since America's first exploratory steps in space with the launch of the Explorer I satellite in 1958, NASA has broadened its scientific reach with an increasingly sophisticated series of robotic missions that have visited asteroids, impacted comet nuclei, orbited the gas giants Jupiter and Saturn, imaged the Sun in stereo, observed planets around distant stars, and looked back in time to moments after the Big Bang. At the same time, NASA has studied Earth from space with increasing detail. The Agency has used its unique perspective from space in pursuit of answers to profound science questions: How and why are Earth's climate and environment changing? How do planets, stars, and galaxies originate? Is Earth the only source of life? How did the universe begin and what is its destiny?

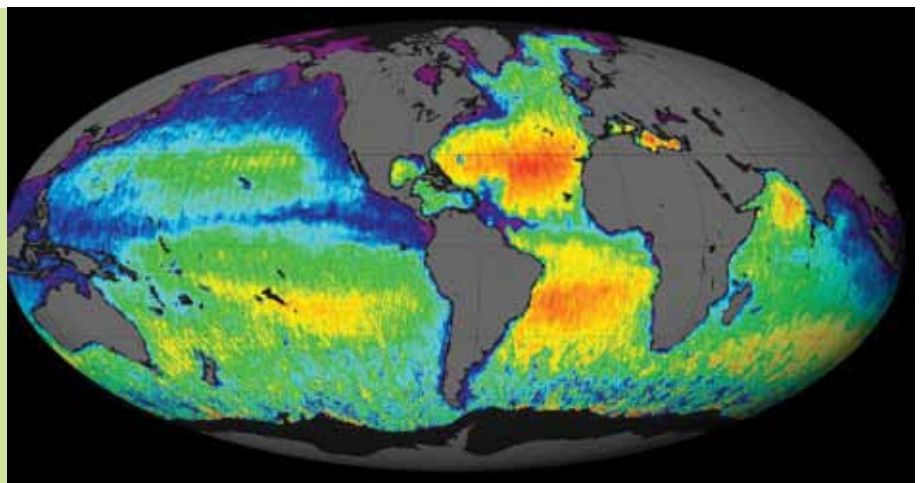
NASA develops, operates, and mines data from science missions that will have a global impact on understanding humankind's place in the universe and the sustainability of Earth, guided by priorities set by the Nation's best scientific minds through the National Academies' decadal surveys for Earth Science, Heliophysics, Planetary Science, and Astrophysics. NASA's Science Mission Directorate (SMD) is responsible for serving these four themes through portfolios of space missions and mission-enabling programs, including suborbital missions, technology development, research and analysis, and data archival and distribution to sustain progress toward science goals.

Benefits

SMD's programs lay the intellectual foundation for the robotic and human expeditions of the future while meeting today's needs for scientific information to address national concerns, such as climate change, the availability of natural resources, and space weather.

SMD has an essential role in NASA's education mission to inspire the next generation of explorers. The discoveries and new knowledge from missions and research programs consistently engage people's imaginations, inform teachers, and excite students about science and exploration. SMD is committed to using its resources to foster the broad involvement of the Earth and space science communities in education and public outreach with the goal of enhancing the Nation's formal education system and contributing to the broad public understanding of science, mathematics, engineering, and technology. NASA's science education program creates products using NASA's results in Earth Science, Heliophysics, Planetary Science, and Astrophysics research. The program sponsors educational activities at all levels of formal and informal education to provide opportunities for learners of all ages.

NASA's new Aquarius instrument aboard the Argentinian SAC-D spacecraft produced its first global map of the salinity, or saltiness, of Earth's ocean surface, providing an early glimpse of the mission's anticipated discoveries. The image, using data from August 25 to September 11, 2011, shows the water with the highest salinity in red and yellow (the subtropics in the Atlantic) and water with the lowest salinity in blue and purple (rainy belts along the equator, the northernmost Pacific, and around the Indian subcontinent and southeast Asia). Find out more about this image, including the grams of salt per kilogram of water attributed to each color. (Credit: NASA/GSFC/JPL-Caltech)



Risks to Achieving Strategic Goal 2

Cost and Availability of Expendable Launch Vehicles: NASA continues to have concerns about the availability, reliability, and increased cost of expendable launch vehicle (ELV) options. Over the course of the last decade, the Delta II has been the workhorse for launching many robotic mid-sized spacecraft. Without this option, NASA has access only to costlier evolved ELVs (Delta IV, Atlas V), which were designed to launch payloads larger than required for many of the missions identified in the NASA Science Plan. Options in the small and medium classes are limited by the lack of reliable, NASA-certified launch vehicles. Possible cost growth in the evolved ELV class is an additional source of concern.

These problems will persist until more competitively priced new commercial launch vehicles become available and demonstrate reliability, potentially reducing the cost of launching missions and facilitating a return of commercial customers to U.S. launchers. In the wake of the launch vehicle failures on two NASA Earth Science missions, the Orbiting Carbon Observatory (OCO) in 2009 and Glory in 2011, the reliability of launch vehicles in this size range is keenly recognized as an aspect of this risk.

International Partnerships: NASA's science portfolio depends on solid, significant, and reliable international partnerships. These partnerships can help to defray costs and balance risks across the partners. In addition, these partnerships contribute significantly to a shared scientific understanding and ownership which greatly assists in advancing scientific understanding.

While international partnerships can help maintain higher effective mission flight rates in a reduced budget environment, they also introduce increased management complexities, as well as technical and programmatic risks. The proper balancing of these risks and rewards requires careful definition of partner interfaces and responsibilities.

Availability of Plutonium-238: The supply of Plutonium-238 (Pu-238) remains a limiting factor in the exploration of the solar system. NASA has already rescoped New Frontiers-3 due to the limited supply of the Pu-238. NASA requires Pu-238 to make power for missions that travel too far from the Sun for solar power generation. Russia has suspended implementation of its contract with the Department of Energy (DOE) for purchase of Russia's remaining supplies of Pu-238. NASA continues to explore its options with the DOE, and gained appropriation of funds for FY 2011 to begin analyzing the best approach to reestablish the supply.

Outcome 2.1

Advance Earth system science to meet the challenges of climate and environmental change.

NASA's Earth Science theme advances knowledge of the integrated Earth system, the global atmosphere, oceans (including sea ice), land surfaces, ecosystems, and interactions between all elements, including the impacts of humans. Earth Science uses a balanced portfolio of flight programs, research, technology development, and applied sciences to achieve its objectives—and serve national and international needs—in these areas.

The Earth Science Research Program advances understanding of the Earth system, its components and their interactions, its changes, and the consequences of these changes for life. The program pioneers the use of remote sensing data, primarily space-based, and sponsors basic disciplinary and interdisciplinary research, Earth system modeling efforts, the Airborne Science project (which provides access to aircraft and unmanned aircraft systems), and supercomputing efforts supporting a variety of programs, as well as education and outreach.

Earth Science completed several important mission milestones during the fiscal year. Many of these missions will serve more than one science objective.

- On June 7, 2011, NASA completed the Aquarius Launch Readiness Review (LRR), the last review of the spacecraft, its launch vehicle, and launch systems to ensure everything is ready. The mission launched on June 10 and began operations—"tasting" the saltiness of Earth's ocean surface—in September.
- Earth Science released the Earth Venture (EV)-2 Announcement of Opportunity on June 17, 2011, with the proposals received in September. Earth Venture is an element within Earth Science's Earth System Science Pathfinder Program, which conducts low-to-moderate cost, small-to-medium sized, competitively selected, principal investigator-led Earth science investigations.
- A review team completed the Mission Operations Review (MOR) for the Landsat Data Continuity Mission (LDCM) on October 28, 2010. They assessed the program's flight concept of operations, project management, operations and sustainment plans, safety and mission assurance, and other program aspects. The launch is planned for the first quarter of FY 2013.
- A review team completed the NPOESS Preparatory Project (NPP) Mission Readiness Review (MRR) on September 6, 2011. Like an LRR, the MRR determines if all systems are ready for a successful launch. MRR is distinguished from an LRR in that MRR also evaluates the readiness of the mission plan to accomplish the mission objectives. Earth Science kicked off FY 2012 with the successful launch of NPP on October 28.

Understanding changes in the ozone layer, air quality, and aspects of atmospheric composition

Using aircraft and satellites to study cirrus clouds

In the past year, NASA researchers conducted an airborne field campaign to improve the characterization of mid-latitude cirrus clouds, the thin, wispy clouds blown by high winds into long streamers. The campaign, called Measurements from the Mid-latitude Airborne Cirrus Properties Experiment (MACPEX), was designed to fill a critical gap in scientists' knowledge about the microphysical properties of mid-latitude cirrus.

Information gained from MACPEX about the sizes, concentrations, and water contents in cirrus clouds is being used to improve basic understanding of cirrus formation and evolution, provide improved characterization of cloud properties for Earth system models, and enhance remote sensing retrieval algorithms (which transform satellite measurements into geophysical parameters—data products that can be used by researchers).

The researchers used NASA's WB-57 aircraft to fly over the continental U.S. and the Gulf of Mexico during March and April 2011. The WB-57 payload included an extensive array of instruments for measuring cirrus properties, aerosols, water vapor, tracers, and meteorological conditions. The MACPEX instrument suite employed recent advances in instrument design and analysis techniques that have mitigated chronic problems with previous instrumentation. To help validate the data, the MACPEX researchers coordinated many of the flights with observations from two satellites from the A-train

formation, the [Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation \(CALIPSO\)](#) and CloudSat, and data from ground based instruments at the Department of Energy's [Southern Great Plains](#) site for validation. Earth Science will use the detailed measurements to better characterize cloud properties for incorporation into global climate models.

DISCOVERing better ways to monitor air pollutants

The Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) mission is a four-year Earth Venture-funded campaign to improve the use of satellites to observe and conduct research on air quality in the lower atmosphere. A challenge for Earth-observing satellites measuring air quality is to distinguish between pollution high in the atmosphere and that near the surface where people live and breathe. DISCOVER-AQ will tackle this challenge through targeted, simultaneous airborne observations at high and low altitudes and ground-based observations. The campaign results will enable improvements in scientists' ability to monitor pollution from satellites, so that they can make better air quality forecasts, more accurately determine the sources of pollutants in the air and more closely determine the fluctuations in emissions levels.

The campaign employs NASA aircraft to make a series of flights with scientific instruments onboard to measure gaseous and particulate pollution. The series of flights—which will be made by NASA [Langley Research Center's](#) King Air and NASA's P-3B—commenced over the Baltimore-Washington, DC, area during summer 2011. Future flight campaigns may be conducted in Houston (2013) and Sacramento (2013), with a final site in 2014 to be determined.

The measurements were taken in concert with ground observations to shed light on how satellites could be used to make similar, consistent measurements over time, with the ultimate goal of putting better data in the hands of policymakers, elected officials, and scientists. Visit the [DISCOVER-AQ site](#) to find out more about the 2011 mission, how the data is being used, and some of the results to date.

Assessing the global impact of black carbon

Black carbon exists as particles in the atmosphere and is a major component of soot. It has significant human health and climate impacts. At ground level, ozone is an air pollutant harmful to human health and ecosystems, and throughout the troposphere (the atmosphere's lowest layer) is also a significant greenhouse gas. In 2009, the [United Nations Environment Programme \(UNEP\)](#) was asked to organize an assessment to provide a scientifically credible basis for informed decision-making on black carbon issues. The reports from that assessment, as well as the 2010 report of the UNEP-led International Ozone Assessment, were both published this year.

UNEP provides leadership and encourages partnership in caring for the environment. NASA scientists and NASA-funded researchers participated and served in leadership roles in this activity. The assessment also used data from NASA satellites ([Aura](#) and past satellites and instruments like the [Total Ozone Mapping Spectrometer \(TOMS\)](#), the [Stratospheric Aerosol and Gas Experiment \(SAGE\)](#), and the [Upper Atmosphere Research Satellite \(UARS\)](#)), data from ground-based networks (the [Advanced Global Atmospheric Gases Experiment \(AGAGE\)](#) and the [Network for the Detection of Atmospheric Composition Change \(NDACC\)](#)), and atmospheric models.

The assessment team looked at the challenges created by black carbon in the atmosphere, like its contribution to the changing climate, melting snow and ice around the world, and reduced crop yields. Then they examined the potential effects of reduced emissions and recommended responses. The result was a comprehensive analysis of drivers of emissions, trends in concentrations, and impacts on climate, human health, and ecosystems of black carbon, as well as tropospheric ozone and its precursors. Black carbon, tropospheric ozone, and methane are often referred to as short-lived climate forcers, as they have a short lifetime in the atmosphere (days to about a decade) relative to carbon dioxide.



NASA's WB-57 taxis along the runway before going on a MACPEX flight. The wings carry instruments contained in "spearpods" and several other instruments bristle near the underside of the aircraft's nose. (Credit: NASA)

The assessment determined that under current policies, emissions of black carbon and ozone precursors are expected globally either to increase or to remain roughly constant unless further mitigation action is taken. It also cited scientific evidence and new analyses that demonstrate that control of black carbon particles and tropospheric ozone through rapid implementation of proven emission reduction measures would have immediate and multiple benefits for human well-being.

Stratospheric aerosol layer: impact of volcanic eruptions

Researchers explored the variability of stratospheric aerosol loading between 1985 and 2010 with measurements from multiple spaceborne instruments, including [SAGE II](#), [CALIPSO](#), and sensors on European and Canadian platforms, [GOMOS/ENVISAT](#) and [SIRIS/Odin](#). Following the 1991 eruption of Mount Pinatubo, stratospheric aerosol levels increased by as much as two orders of magnitude and only reached “background levels” between 1998 and 2002. From 2002 onwards, a systematic increase in stratospheric aerosols has been reported by a number of investigators.

Recently, studies done using ground-based lidar measurements have tentatively attributed this trend to an increase of sulfur dioxide entering the stratosphere associated with coal burning in Southeast Asia. However, these satellite measurements demonstrate that the observed trend is mainly driven by a series of moderate but increasingly intense volcanic eruptions primarily at tropical latitudes. These events injected sulfur directly to altitudes between 11 and more than 12 miles (18 and 20 kilometers). The resulting aerosol particles are slowly lofted into the middle stratosphere and are eventually transported to higher latitudes.

A [study published in July 2011](#) shows that none of the climate models have included the effect of the slow increase in stratospheric aerosols during the past decade. Researchers also have used these measurements to assess the role of aerosols in radiative forcing (the change in the balance between the incoming and outgoing radiation energy between the troposphere and stratosphere) and their impact to climate model calculations of global change. If these measured increasing trends were not taken into account, climate model projects would overestimate radiative forcing and global warming in coming decades.

Seasonal variation of black carbon transport from Asia to the Arctic

Researchers conducted extensive measurements of black carbon aerosol in and near the North American Arctic during the [Arctic Research of the Composition of the Troposphere from Aircraft and Satellites \(ARCTAS\) aircraft campaign](#) in April and June–July 2008, and important new results were published by NASA-funded researchers in 2011. Analyses of observations from the ARCTAS aircraft mission provided new perspectives on the transport of pollution to the Arctic and its climate implications. They showed that the Arctic is subject to a complex combination of influences from Asian, European, and North American anthropogenic (human-made) pollution, as well as Russian fires, known as biomass burning.

The researchers found that both fossil fuel and biomass burning are major contributors of black carbon in the Arctic. Further, the results show that the impact of black carbon emitted from anthropogenic sources in East Asia on the Arctic was very limited in both spring and summer. The biomass burning emissions in Russia in spring were found to be the most important sources of black carbon transported to the North American Arctic.

ARCTAS also revealed that the prominent satellite observations of Bromine Monoxide hotspots in polar spring are not due to boundary layer bromine, as previously thought, but to tropopause depressions (the point between the troposphere and the stratosphere where air stops cooling with height and becomes almost completely dry) combined with higher-than-expected inorganic bromine in the lower stratosphere. Bromine has been linked to ozone destruction, so elevated bromine has important consequences for ozone in the Arctic stratosphere and troposphere.

Radiative effects of biomass burning aerosols

Direct and semidirect radiative effects of biomass burning aerosols from southern African fires during July through October were investigated using 20-year runs of the Community Atmospheric Model (CAM) coupled to a slab ocean model. Aerosol optical depth is constrained using observations in clear skies from [MODIS](#) and for aerosol layers above clouds



NASA's P-3, one of the aircraft used for the ARCTAS campaign, is ready to be moved into the airfield hangar after its arrival at Thule Air Base, Greenland on April 8, 2008. (Credit: NASA)

from CALIPSO. Over the ocean, where the aerosol layers are primarily located above cloud, negative top of atmosphere semidirect radiative effects associated with increased low cloud cover dominate over a weaker positive all-sky direct radiative effect. In contrast, over the land where the aerosols are often below or within cloud layers, reductions in cloud liquid water path lead to a positive semidirect radiative effect that dominates over a near-zero direct radiative effect. Over the ocean, the cloud response can be understood as a response to increased lower tropospheric stability, which is caused both by radiative heating in overlying layers and surface cooling in response to direct aerosol forcing. Over land, decreased liquid water path is consistent with weaker convection driven by increased static stability. Over the entire region, the overall top of atmosphere radiative effect from the biomass burning aerosols is almost zero due to opposing effects over the land and ocean. However, the surface forcing is strongly negative, which leads to a reduction in precipitation and also a reduction in sensible heat flux. The results highlight the importance of semidirect radiative effects and precipitation responses for determining the climatic effects of aerosols in the African region.

Using NASA capabilities to improve extreme weather monitoring and prediction

Getting a GRIP on tropical storms and hurricanes

In August-September 2010, NASA conducted the Genesis and Rapid Intensification Processes (GRIP) field experiment to better understand the physical processes that control hurricane formation and intensity change.

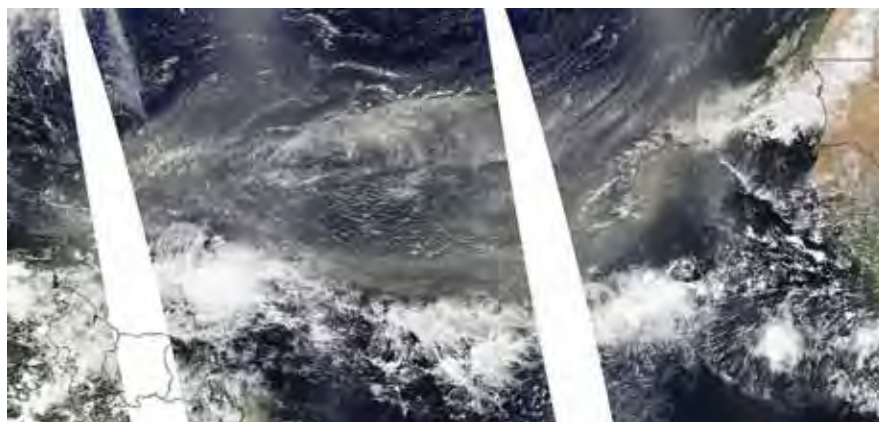
NASA and National Science Foundation aircraft teamed up to perform coordinated flights for the genesis of Hurricane Karl and Tropical Storm Matthew and the non-development of the remnants of Tropical Storm Gaston. NASA's space and airborne observational capabilities put it in a unique position to assist the hurricane research community in addressing shortcomings in the current state of the science. The relatively recent launch of several new satellites, the prospect of using high-altitude unmanned aircraft systems for hurricane surveillance, and the emergence of new remote sensing technologies offer new research tools that need to be explored and validated. New remote sensing instruments for wind and temperature may lead to improved characterization of storm structure and environment. In June 2011, the GRIP project hosted a science meeting to share some of the results. The presentations are available at http://grip.nsstc.nasa.gov/science_meeting.html.

SPoRT transitions important data to Weather Forecasting Offices

The Short-term Prediction Research and Transition (SPoRT) Center is a NASA project to transition unique observations and research capabilities to the operational weather community to improve short-term forecasts on a regional scale. In fall 2010, the National Weather Service's Office of Science and Technology asked SPoRT to transition experimental ocean surface wind vectors derived from WindSat to selected forecast offices around the country. Developed by the Naval Research Laboratory, WindSat measures ocean surface, wind speed, and wind direction from space. The data is currently undergoing evaluation by forecasters in the Alaska region and the Monterey Weather Forecasting Office.

Demonstrating the connection between the Saharan Air Layer and hurricanes

A study using data from a suite of instruments aboard Aqua—the Atmospheric Infrared Sounder (AIRS) and Advanced Microwave Sounding Unit (AMSU)—demonstrated that information about intensely dry, warm air associated with the Saharan Air Layer improves hurricane simulations. It also demonstrated that the Saharan Air Layer, which often sits over the cooler, more humid surface air of the Atlantic Ocean, contributes to hurricane formation but suppresses hurricane intensification.



A well-defined plume of dust swept across the entire Atlantic Ocean on June 24, 2009. In this photo-like image taken by the MODIS instrument on Aqua in three consecutive overpasses, the dust stretches from its origins in Africa's Sahara Desert to the Lesser Antilles Islands on the eastern edge of the Caribbean Sea. [Read more about this image.](#) (Credit: NASA/J. Schmaltz, MODIS Rapid Response)

Better forecasting of precipitation with AIRS

The impact of assimilating quality-controlled AIRS temperature retrievals obtained from partially cloudy regions was assessed in a recent NASA study, with focus on precipitation produced by the Goddard Earth Observing System Model (GEOS)-5 data assimilation and forecasting system for three tropical cyclones. Scientists found that the precipitation analysis obtained when assimilating AIRS cloudy retrievals can capture regions of heavy precipitation associated with tropical cyclones much better than without AIRS data or when using AIRS clear-sky radiances. The corresponding precipitation forecasts initialized from AIRS analysis showed better performance than forecasts initialized from previous analyses up to two-day forecasting.

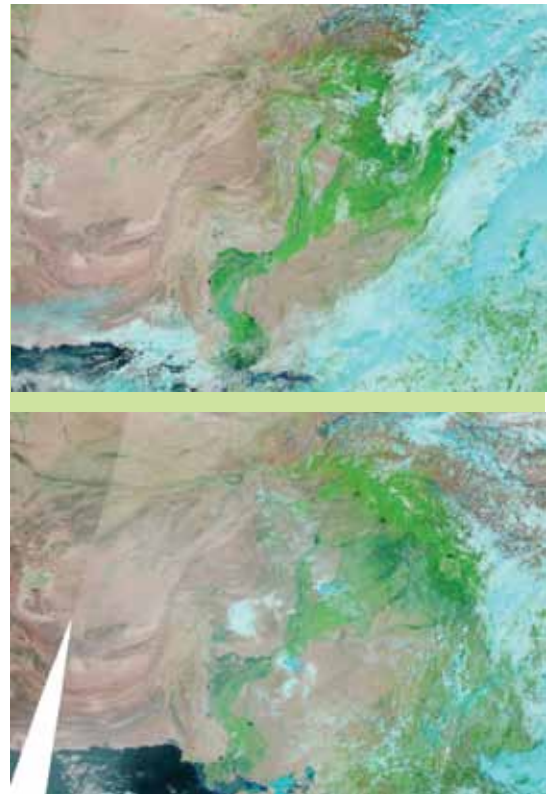
Satellite data connect two super-extreme weather events of 2010

NASA satellite and re-analyses data show that the two super-extreme weather events in the summer of 2010—the Russian heat wave and the Pakistan flood—were physically connected. The development of an atmospheric blocking high associated with Russian heat wave set off a large-scale atmospheric Rossby wave, which was instrumental in triggering torrential rain over northern Pakistan.

The recent study by NASA scientists found that an abnormal Rossby wave sparked extreme heat and persistent wildfires in Russia as well as unusual downstream wind patterns that shifted rainfall in the Indian monsoon region and fueled heavy flooding in Pakistan. Atmospheric Rossby waves are giant flows of high-altitude winds that are formed by the shape and rotation of Earth. Always moving from east to west, they have major effects on large-scale ocean circulation, weather, and climate, and they form the jet streams. The Russian heat wave started before the floods, but both events attained maximum strength at approximately the same time, the researchers found by analyzing NASA satellite data measuring land surface temperature, precipitation intensity, and wildfire activity. Under normal summertime conditions, the jet stream pushes weather fronts through Eurasia in four or five days, but in July 2010 a large-scale, stagnant weather pattern—known as an Omega blocking event—developed over a high-pressure ridge above western Russia. This blocking event, which divided the jet stream, had the effect of slowing the Rossby wave and prevented the normal progression of weather systems from west to east. As a result, a large region of high pressure formed over Russia and trapped a hot, dry air mass that stopped precipitation and dried out the vegetation.

Meanwhile, the blocking pattern created unusual downstream wind patterns over Pakistan. Areas of low pressure on the leading edge of the Rossby wave formed in response to the high that pulled cold, dry Siberian air into lower latitudes. This high brought upper level air disturbances farther south than is typical, which helped shift the entire monsoon rainfall system north and west, bringing heavy monsoon rains squarely over the northern part of Pakistan.

While the new study highlights the degree of interconnection that can exist between two seemingly unrelated weather events, many questions remain. For example, why did such a powerful blocking high form in the first place? And did some particular process occurring on the land or in the atmosphere sustain and strengthen it? Furthermore, graphite-like dark particles in wildfire smoke (a type of aerosol called black carbon) may have helped burn clouds away, making the surface even drier and more fire prone.



Monsoon floods struck Pakistan's southern Sindh Province in August 2011. A drain breach in Badin District left residents marooned on dry spots separated by high water. Terra's MODIS instrument captured these images on August 16, 2011 (top), and July 17, 2011 (bottom). The images show southern Pakistan, near the coast and near the border with India. Both images use a combination of visible and infrared light to increase contrast between water and land. Water ranges in color from electric blue to navy. Vegetation is green, and bare ground is pink-beige. Clouds are pale blue-green. (Credit: NASA/MODIS Rapid Response Team)

Understanding land cover, biodiversity, and a changing ecosystem

Publishing research results for the North American Carbon Program

In the past year, NASA research has advanced in quantifying the state of global land cover, analyzing interannual variability and trends in terrestrial and marine ecosystems, and explaining the processes that control productivity and carbon cycling, one of the most important cycles of Earth, allowing for carbon to be recycled and reused throughout the biosphere and all of its organisms. The researchers have published many peer reviewed journal articles on the results of the interagency North American Carbon Program's (NACP's) interim synthesis studies.

Researchers have characterized and, in several cases, quantified the effects of differing types of disturbances, caused by natural phenomena as well as by human actions, on carbon sources and sinks at continental scales. Researchers will use this new understanding, along with the findings of an on-going model intercomparison study for NACP, to improve carbon cycling models.

National Biomass and Carbon Data Set released in April 2011

Hectare-scale maps of canopy height, aboveground biomass, and associated carbon stock for the forests and woodlands of the contiguous United States were released to the public. The National Biomass and Carbon Dataset (NBCD) project produced maps of these key forest attributes at an unprecedented spatial resolution of 97.5 feet (30 meters). The project was initiated in 2005 with support from NASA, the U.S. Geological Survey, and the U.S. Department of Agriculture's Forest Service. NASA space-borne imagery (Shuttle Radar Topography Mission and Landsat-7), land use/land cover information, topographic survey data, and extensive forest inventory data were combined. Across 66 individual mapping zones, spatial data, field observations, and statistical models were used to generate the canopy height, above ground biomass, and carbon stock maps, which were then merged to form national-scale products.

The data set is available at http://www.whrc.org/mapping/nbcd/nbcd_reg.html.

Analyzing phytoplankton's role in the carbon cycle

In 2010, researchers published the first satellite-based analysis of major phytoplankton classes (micro-, nano-, and picophytoplankton) in the world's oceans, and their contribution to primary production. Primary production is a measure of the amount of biomass produced through photosynthesis by plants. The analysis of interannual variations revealed large anomalies in class-specific primary production as compared to the 10-year mean cycle in both the productive North Atlantic basin and the more stable equatorial Pacific upwelling. Assessing climatology and interannual changes in primary production associated with three major phytoplankton classes within the global ocean represents a significant contribution to our ability to understand and quantify carbon cycling in the upper ocean.

Phytoplankton are microscopic organisms that live in both salty and fresh water. Like land plants, phytoplankton have chlorophyll to capture sunlight, and they use photosynthesis to turn it into chemical energy. They also consume carbon dioxide and release oxygen. Previous research has focused on phytoplankton as a single group. The researchers note that the different function, structure, and size of phytoplankton communities influence many biogeochemical processes important to primary production. The researchers applied algorithms that allowed them to determine distinct groups of phytoplankton from ocean color remote sensing data gathered by NASA's Sea-viewing Wide Field-of-view Sensor (SeaWiFS). The algorithms cannot directly quantify the production of each phytoplankton group; that information was interpreted by the researchers.

The researchers found that microphytoplankton appear as a major contributor to total primary production in coastal upwelling systems (70 percent) and temperate and subpolar regions (50 percent) during the spring–summer season. Picophytoplankton make their biggest contribution (45 percent) in subtropical oligotrophic (having low accumulation of dissolved nutrient salt, sparse algae and other organisms, but high oxygen content) gyres. Nanophytoplankton provide a ubiquitous, substantial contribution (30 to 60 percent). There appears to be very little interannual variability in the annual cycle of primary production for total phytoplankton over the global ocean. However, when the researchers looked at the different phytoplankton classes, they saw different degrees of variability. In contrast to the observations made on the global scale, the regional scale analysis reveals large year-to-year variations in total and class-specific primary production.

Publishing findings on carbon cycle and biodiversity

A number of NASA-supported projects have used remotely sensed data and ecological models to define the habitats of organisms and how they change, or are likely to change, in response to physical, chemical, and biological variations in their surroundings. These projects are not only important for understanding how organisms respond to land cover change and other changes in their environment, but they have large implications for managing natural systems to promote the conservation of biodiversity.

In 2011, an additional [special issue section](#) of the *Journal of Geophysical Research* reported on results of the [Southern Ocean Gas Exchange Experiment \(SO GasEx\)](#), which studied the transfer of gases like carbon dioxide from ocean to atmosphere. Funded by NASA, the [National Science Foundation](#), and [NOAA](#), the multidisciplinary field process study aimed to better understand how air-sea gas exchange affects and is affected by Southern Ocean biogeochemistry. The journal also published a special collection of papers on the study of vegetation three-dimensional structure, which includes canopy height and density, from space. Because of the inherent difficulty of measuring forested vegetation three-dimensional structure on the ground, this important component of biodiversity and habitat has mostly been restricted to local measurements or, for larger scales, generalizations. Spaceborne lidar and remote sensing instruments have made it possible to derive accurate three-dimensional measurements and create models of biomass structure and changes.

Quantifying water reservoirs and assessing global water cycle changes and water quality

Multiple satellite data sources, improved models and field campaigns

Over the past year, NASA has continued its progress improving its description of the water cycle, including the size and movement between its stores. Coincident use of multiple satellite data sources (e.g., [Advanced Microwave Scanning Radiometer for EOS \(AMSR-E\)](#), [Tropical Rainfall Measuring Mission \(TRMM\)](#), and [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#)), especially those of different but linked variables have led to improvement both in the quantification of the water cycle and the uncertainty estimates of its components, with both groundwater and total storage two new variables being provided. Furthermore, [Gravity Recovery and Climate Experiment \(GRACE\)](#) data has been used to provide large area estimates of the change in total water storage of the land that by definition has to equal the sum of precipitation, evaporation, and run-off. Refinement has been made globally, regionally, and on annual and monthly time scales.

Following the study published in 2009 that used GRACE data to identify current rates of groundwater depletion in India, a recent study showed that California's major water source (the Sierra Nevada mountains) and America's fruit basket (California's Central Valley) were also experiencing significant rates of groundwater depletion. During the 2003-2010 time period studied, the combined Sacramento-San Joaquin River Basins lost the equivalent volume of Lake Mead in freshwater, nearly two-thirds of which came from groundwater. The work has resonated across the country, renewing calls for enhanced groundwater management, and garnering support for an accelerated GRACE follow-on mission.

Annually the [Bulletin of the American Meteorological Society](#) releases a "state of the climate" issue. For the first time NASA is able to contribute two new variables to this report. GRACE data combined with large-scale hydrological modeling are able to contribute important information about the "climate" of Groundwater and Total Water Storage. Not only is this affirmation that these variables are important but also highlights that satellite remote sensing is a requirement for this climate variable.

Studies leverage multiple field campaigns for vital downscaling approaches

A NASA supported study has allowed for the exploitation of data from numerous field studies (e.g., Southern Great Plains and Soil Moisture Experiment) that have been funded in full or in part by NASA over the last two decades. Though different field campaigns emphasized different scientific objectives, this study was able to coalesce the information content of them all to understand aspects of soil moisture variability. The study used this to better understand the information captured by remote sensing at different spatial resolutions, especially revealing controlling aspects on the variability (i.e., ecological, topographical, and others). This has resulted in important guidance on methods of creating and using in situ gauges to evaluate remote sensing products. It also has led to ways to downscale soil moisture, either observations or models. This is particularly important in making scientific research data more readily usable by agriculture and water resource managers.

Gaining a better understanding of the roles of the ocean, atmosphere, land, and ice in the climate system

NASA continues to provide specialized support for research to better understand the interactions of the oceans, atmosphere, and ice in the Earth climate system. Recent efforts have focused on the integration of data acquired from satellites, aircraft, and ground networks into climate modeling at global and regional scales. Over the past year, these observations continue to show higher than climatologically normal surface temperatures, indicative of a warming climate.

Monitoring global sea level and sea surface temperature trends and climate variability

For the past 18 years, the U.S.–French Jason-1, Jason-2, and Topex/Poseidon satellite missions have provided a long-term time series of globally averaged mean sea level, revealing the overall trend to be increasing at 0.14 inches (3.4 millimeters) per year. In addition, its interannual variability was closely correlated with the El Niño–Southern Oscillation phenomenon, which serves as a reminder that short-term variations (five years or less) do not necessarily signify changes in global warming. Rather, they can be attributed to changes in oceanic heat content, or more likely, to shifting patterns of precipitation over land and ocean.

Satellite sea surface temperature data for the past three decades reveal a record anomaly within a large mid-latitude region of the south-central Pacific during the mature phase of the 2009–2010 El Niño. The warming in this region was confined to the upper 162.5 feet (50 meters) of the ocean, and has been attributed to wind changes associated with an extreme and persistent anticyclone, with surface heat flux and ocean processes playing equally important roles. This anticyclone also diverted circumpolar westerlies and warm air toward Antarctica, producing three-decade high sea surface temperatures in the Bellingshausen Sea.

The global mean surface temperature was at a record level in 2010, despite a relatively cool equatorial Pacific region and unusually cool conditions over the eastern United States and Eurasia near the end of 2010. The year ended in a statistical tie with 2005 as the warmest year in the Goddard Institute for Space Studies (GISS) temperature record.

In late 2009 to early 2010, the Gravity Recovery and Climate Experiment (GRACE) pair of satellites observed a record increase in ocean bottom pressure over a large mid-latitude region of the southeast Pacific Ocean. This observation suggests that a similar, simultaneous signature in sea surface height, captured by satellite altimeters, was mainly due to mass convergence. Using scatterometer data and atmospheric reanalysis products, along with the GRACE and altimeter data, researchers determined that the joint signal was associated with a strong and persistent anticyclone in late 2009. This driving wind pattern was related to an unusual central Pacific El Niño event, one that is becoming more prevalent than the better-known eastern Pacific El Niño.

Shrinking ice leads to further surface warming

Satellite data during the past year continued to show a decline in Arctic sea ice cover, both in extent and thickness. The minimum extent for September 2011, if reached, would surpass the record minimum established in 2007. Data has shown that thinning and receding Arctic sea ice increases the net ocean-atmosphere heat output and now is playing a role in increasing surface air temperatures in the Arctic. Vanishing sea ice has also been associated with an increase in cloudiness, which reduces the emission of long wave radiation from the Arctic, further increasing temperatures in the region.

Various studies of the Greenland ice sheet highlight the profound ice loss that has occurred there since the 1990s, much of it through fast-flowing outlet glaciers. Furthermore, models suggest that Pine Island Glacier, in west Antarctica, is at risk of losing its ice shelf, which could lead to a dramatic increase in ice flow there. These changes, in all aspects of the cryosphere (the areas of Earth where water is in solid form such as sea ice, lake ice, snow, and glaciers), emphasize the need for continued monitoring and improved modeling.

Getting better data and advanced computing to the research community

Over the past year, NASA's investments in both capacity and new capabilities in data processing have enabled scientists to transform the output from remote sensing and in-situ instruments into the scientific measurements needed to improve both understanding and predictive capability of the oceans, atmosphere and ice. These tools have accelerated the process of scientific discovery by permitting the research community to assimilate the large quantities of data obtained and have ensured the stewardship of that data over the long periods of time needed to understand the climate system's behavior. Similarly, predictive and diagnostic modeling continues to make significant contributions to the understanding of the Earth system. Facilitated by increases in supercomputing capabilities, NASA models were pushed to higher

resolutions. Higher resolution simulations show improved fidelity to observations. Significant improvements have been made in coupling regional and global climate models, developing tools that will improve understanding of regional climate change.

Understanding the dynamics of Earth's surface and interior to enhance resilience and mitigation to natural hazards

NASA begins building new, high-accuracy receivers

Following earlier investments, NASA initiated the development of a new Global Navigation Satellite System (GNSS) spaceborne receiver, the Tri-GNSS (Tri-G) during 2010. This receiver will replace the very successful BlackJack Global Positioning System (GPS) receiver. The prototype receiver will be available in 2013. GNSS receivers detect, decode, and process signals from the GNSS satellites (currently GPS and Global Navigation Satellite System (GLONASS) and, in the future, Galileo). High-accuracy measurements of the change in receiver locations over time allow researchers to study the motions of tectonic plates, displacements associated with earthquakes, and Earth orientation. The receiver also will provide the needed positioning and timing capability required for the missions recommended by the National Academies' [Earth science decadal survey](#). NASA's [Crustal Dynamics Data Information System \(CDDIS\)](#) supports data archiving and distribution activities for the space geodesy and geodynamics community, including [GNSS](#) data.

GRACE again detects crustal dilatation at a large subduction zone earthquake

Scientists have noted small but detectable changes in the [Gravity Recovery and Climate Experiment \(GRACE\)](#) satellites' relative trajectory after the M8.8 Maule, Chile, earthquake on February 27, 2010, that can be used to delineate the shift in the gravity field. A gravity anomaly of -5 mGal with a spatial scale of 308 miles (500 kilometers) was found east of the epicenter after the earthquake. Based on coseismic models, the long wavelength negative gravity change is primarily the result of crustal dilatation as well as surface subsidence in the onland region. The offshore positive gravity anomaly predicted from finite fault coseismic models is considerably smaller because the gravity changes due to surface uplift and interior deformation are opposite in polarity. Research suggests a role for large-scale gravity observations in deciphering changes of Earth's interior during great earthquakes by filling in the seldom-observed long wavelength spectrum of earthquake deformations as a complement to surface geodetic measurements and seismic data.

Providing natural hazard data quickly to help emergency response

The Advanced Rapid Imaging and Analysis (ARIA) Center is an emergency response project under development at the [Jet Propulsion Laboratory](#) and the [California Institute of Technology](#). The ARIA Center plans to provide the infrastructure to generate imaging products, using NASA resources, in near real-time to aid the Nation in responding to natural disasters like earthquakes, volcanic activity, and landslides.

An initial effort, through a subproject called ARIA-EQ, has focused on responding to significant earthquakes and will provide a prototype near real-time global large earthquakes analysis system using a combination of seismological, geodetic, and tsunami observations. The March 11, 2011, Tohoku earthquake in Japan demonstrated the true potential of this team to generate rapid, accurate information based on seismic and geodetic information. The [U.S. Geological Survey](#) and other organizations used ARIA-EQ products to provide situational awareness for the event, as well as to identify neighboring zones of concern with respect to similar future earthquakes. ARIA data, along with other Earth observation data, of this event is available at the [Tohoku Event Supersite](#).

Using NASA information in decision-making activities for societal benefits.

Starting new projects

In FY 2011, the [Applied Sciences Program](#) awarded 35 new decision-support applications projects from an interagency solicitation focused on using Earth observations to help managers assess land-use vulnerability and craft practical strategies for land management in a changing climate (see the [Research Opportunities in Space and Earth Sciences \(ROSES\)-2010 solicitation](#)).

The Applied Sciences Program initiated a new [Air Quality Applied Sciences Team \(AQAST\)](#) to assist state and Federal air quality agencies in using the latest scientific knowledge and remote sensing techniques. AQAST has the Earth science resources, from satellites and suborbital platforms, to carry out quick-turnaround research responding to urgent and evolving needs of air quality management.

A fiscal year of using NASA products for public benefit

NASA teamed with the [U.S. Drought Monitor](#) to incorporate drought indicators for soil moisture and ground-water based on data from the [GRACE](#) satellite. Drought Monitor is a synthesis of multiple indices and impacts that represents a consensus of Federal and academic scientists. The Drought Monitor product is evolving and being refined over time to better reflect decision-makers needs and to incorporate new data products. At an April 2011 Water Resources Workshop, the team delivered the first drought indicator products, meeting a major milestone in the project.

In October 2010, the joint NASA–U.S. Agency for International Development (USAID) SERVIR Program launched a new, third hub to support the developing countries of the Hindu Kush–Himalayan region in environmental management, disaster response, and public health. Approximately 1.3 billion people depend on the ecosystem services provided by the Himalayan mountains, yet the region is known as Earth’s “third pole” because of its inaccessibility and the vast amount of water stored there in the form of ice and snow. SERVIR is integrating Earth science data from NASA satellites with geospatial information products from other government agencies to support and expand SERVIR–Himalaya’s host institution’s focus on critical regional issues such as disaster management, biodiversity conservation, trans-boundary air pollution, snow and glacier monitoring, mountain ecosystem management, and climate change adaptation. During the Pakistan floods of late 2010, this new hub provided vital data products, helping aid agencies direct patients to alternate health care facilities not threatened by the floods. (Read more about the [new SERVIR hub](#).)



USAID Administrator Rajiv Shah, left, and NASA Administrator Charles Bolden shake hands after signing a five-year Memorandum of Understanding on April 25, 2011. The agreement formalizes ongoing agency collaborations that use Earth science data to address developmental challenges and to assist in disaster mitigation and humanitarian responses. The agreement also encourages NASA and USAID to apply geospatial technologies to solve development challenges affecting the United States and developing countries. (Credit: NASA/P.E. Alers)

SERVIR, which gets its name from the Spanish word meaning “to serve,” also has a hub located at the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) in Panama and the Regional Center for Mapping of Resources for Development (RCMRD) in Kenya. During FY 2011, SERVIR–Mesoamerica aided the preparation and response to Tropical Storm Emily, which was the 50th extreme event it had aided in Latin America and the Caribbean since 2004. SERVIR–Mesoamerica also has developed a pilot project for the Geospatial Information System for Fire Management (SIGMA-I) in Guatemala to generate products that highlight the importance of systematic and informed planning for prevention and control of wildfires, which have been damaging wild areas and savannas. SERVIR–East Africa worked with 14 land managers from Kenya, Tanzania, Uganda, Rwanda, and Ethiopia to create wall-to-wall land cover maps for their respective countries. The SERVIR–Africa and the Kenya Meteorological Department are teaming to give decision-makers flood forecasts with longer lead-times ([read more on this story](#)).

The [DEVELOP Program](#), an internship program for young professionals to develop Earth science applications, set new records this fiscal year. DEVELOP received 716 student nominations, accepted 239 students (33 percent of those nominated), and conducted 49 projects. The program amplified its outreach efforts by creating virtual project poster sessions—people online anywhere could experience the students’ project results and improve their own understanding of NASA Earth science capabilities. In FY 2012, DEVELOP plans to establish new nodes in Missouri and Colorado, expanding the number of applications focused on the Midwest and Mountain West.

In spring 2011, the Applied Sciences Program’s [Gulf of Mexico Initiative](#) mapped the floodwaters of the lower Mississippi River. This included mapping the extent of flooding of Louisiana’s Atchafalaya River Basin due to the opening of the Morganza spillway and tracking the plume of floodwaters from the Bonne Carré spillway through Lake Pontchartrain and into the Gulf of Mexico. The Gulf of Mexico is a vital economic engine—

A National Space Science and Technology Center (NSSTC) senior research scientist from the University of Alabama in Huntsville trains three researchers from El Salvador to use SERVIR. (Credit: SERVIR)



providing over a billion pounds of fresh seafood every year, thriving shipping ports, and crude oil production—and thriving but sensitive ecological region in the United States. It is vulnerable to both natural and human-made impacts. The program created the Gulf of Mexico Initiative to address coastal management issues using Earth Science's products.

Planning for the future

The Applied Sciences Program pursued efforts to engage the applications community in early stage planning for upcoming satellite missions. The program held an event for end users from the private sector and government focused on environmental conservation to discuss future data needs for applications and to examine potential applications of eight upcoming NASA Earth observing satellites. Key issues for the users were improving higher-level data products, increasing the ease of integration into decision support systems, data accuracy, and visualizations.

Outcome 2.1					
Advance Earth system science to meet the challenges of climate and environment change.					
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS1 Green	8ES01 Green	9ES1 Green	10ES01 Green	ES-11-1 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch at least two missions in support of this objective.					2.1.1.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Aquarius Launch Readiness Review.	None	8ES10 Yellow	9ES4 Green	10ES02 Yellow	ES-11-2 Green
Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing.	7ESS6 Yellow	8ES04 Yellow	9ES2 Green	10ES22 Green	ES-11-3 Yellow
Why NASA rated APG ES-11-3 Yellow: The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.)					
Release Earth Venture 2 (EV-2) Announcement of Opportunity.	None	None	None	None	ES-11-4 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in enabling improved predictive capability for weather and extreme weather events. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS2 Green	8ES02 Green	9ES7 Green	10ES04 Green	ES-11-5 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch at least two missions in support of this objective.					2.1.2.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the Global Precipitation Mission (GPM) Systems Integration Review.	None	8ES06 Yellow	9ES8 Yellow	10ES06 Green	ES-11-6 Yellow
Why NASA rated APG ES-11-6 Yellow: Both the NASA spacecraft and instrument developments are experiencing challenges in subsystem deliveries. These development challenges are resulting from various issues including defects discovered in flight parts, component manufacturing throughput issues and workmanship issues at supply vendors. In addition, the delivery of the JAXA (Japanese space agency)-provided Dual Precipitation Radar (DPR) instrument has been delayed due to disruptions at, and damage to, the test facility resulting from the March 2011 earthquake. Technical issues with the DPR were also identified during environmental testing. It is currently estimated that these challenges will result in a launch readiness delay of eleven months, from July 2013 to June 2014. (See page 178 for the Performance Improvement Plan.)					

FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in quantifying, understanding and predicting changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS3 Green	8ES03 Green	9ES10 Green	10ES07 Green	ES-11-7 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch at least two missions in support of this objective.					2.1.3.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Landsat Data Continuity Mission (LDCM) Mission Operations Review.	None	None	9ES11 Green	10ES08 Green	ES-11-8 Green
Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing.	7ESS6 Yellow	8ES04 Yellow	9ES2 Green	10ES22 Green	ES-11-3 Yellow
Why NASA rated APG ES-11-3 Yellow: The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.4.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in quantifying the key reservoirs and fluxes in the global water cycle and assessing water cycle change and water quality. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS5 Green	8ES05 Green	9ES13 Green	10ES09 Green	ES-11-9 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch at least two missions in support of this objective.					2.1.4.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Soil Moisture Active-Passive (SMAP) Confirmation Review.	None	None	9ES14 Green	10ES10 Yellow	ES-11-10 Yellow
Why NASA rated APG ES-11-10: The SMAP Confirmation Review was delayed to FY 2012 because of difficulties in identifying an acceptable launch vehicle for the mission. NASA's Earth Science program has been impacted by the current limited availability of launch vehicles in the medium size range that is appropriate for most of its missions. (See page 178 for the Performance Improvement Plan.)					
Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing.	7ESS6 Yellow	8ES04 Yellow	9ES2 Green	10ES22 Green	ES-11-3 Yellow
Why NASA rated APG ES-11-3 Yellow: The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.)					
Complete the Global Precipitation Mission (GPM) Systems Integration Review.	None	8ES06 Yellow	9ES8 Yellow	10ES06 Green	ES-11-6 Yellow
Why NASA rated APG ES-11-6 Yellow: Both the NASA spacecraft and instrument developments are experiencing challenges in subsystem deliveries. These development challenges are resulting from various issues including defects discovered in flight parts, component manufacturing throughput issues and workmanship issues at supply vendors. In addition, the delivery of the JAXA (Japanese space agency)-provided Dual Precipitation Radar (DPR) instrument has been delayed due to disruptions at, and damage to, the test facility resulting from the March 2011 earthquake. Technical issues with the DPR were also identified during environmental testing. It is currently estimated that these challenges will result in a launch readiness delay of eleven months, from July 2013 to June 2014. (See page 178 for the Performance Improvement Plan.)					

FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.5.1 Green
FY 2011 Annual Performance Goal	FY 07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding the roles of ocean, atmosphere, land, and ice in the climate system and improving predictive capability for future evolution. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS7 Green	8ES07 Green	9ES15 Green	10ES11 Green	ES-11-11 Green
FY 2011 Performance Goal					FY 2011
HPPG: In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011.					2.1.5.2 Red
Why NASA rated Performance Goal 2.1.5.2 Red: This high priority performance goal was not met, due to the loss of the Glory mission when the fairing from the Taurus XL launch vehicle failed to separate from the rocket. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission was successfully launched on October 28, 2011. (See page 164 for the Performance Improvement Plan.)					
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) Mission Readiness Review.	None	None	None	None	ES-11-12 Green
Complete the Glory Launch Readiness Review.	7ES8 Yellow	8ES09 Yellow	9ES3 Red	10ES21 Yellow	ES-11-13 Red
Why NASA Rated APG ES-11-13 Red: The Glory Launch Readiness Review was completed on February 21, 2011, with a second review completed on March 2, 2011. The spacecraft and instruments were checked out and prepared to successfully begin their mission. However, the Glory mission, which was launched from Vandenberg Air Force Base on March 4, 2011, did not reach orbit due to a mishap with the launch vehicle. Initial evidence suggests that the fairing, which protects the spacecraft during takeoff atop the Taurus XL launch vehicle, did not separate as required, when it reached the appropriate altitude. (See page 164 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
By 2015 launch at least three missions in support of this objective.					2.1.5.3 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the ICESat-2 Spacecraft System Requirements Review.	None	None	9ES16 Yellow	10ES12 Green	ES-11-14 Yellow
Why NASA rated APG ES-11-14 Yellow: The date for the ICESat-2 Systems Requirements Review, has been delayed to December 2011. This review was rescheduled from March 2011 to revisit the mission design and requirements to align with the estimated available budget, moving forward. (See page 179 for the Performance Improvement Plan.)					
Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing.	7ESS6 Yellow	7ES04 Yellow	9ES2 Green	10ES22 Green	ES-11-3 Yellow
Why NASA rated APG ES-11-3 Yellow: The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.6.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in characterizing the dynamics of Earth's surface and interior and forming the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS10 Green	8ES11 Green	9ES17 Green	10ES13 Green	ES-11-15 Green
FY 2011 Performance Goal					FY 2011
By 2015 launch at least one mission in support of this objective.					2.1.6.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the Landsat Data Continuity Mission (LDCM) Mission Operations Review.	None	None	9ES11 Green	10ES08 Green	ES-11-8 Green

FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.1.7.1 Green
FY 2011 Annual Performance Goals	FY 07	FY08	FY09	FY10	FY 2011
Conduct impact analyses of two projects that apply NASA Earth science research to support decision making activities.	7ESS11 Green	8ES012 Green	9ES18 Green	10ES14 Green	ES-11-16 Green
Increase the number of science data products delivered to Earth Observing System Data and Information System (EOSDIS) users.	None	8ES13 Green	9ES19 Green	10ES15 Green	ES-11-17 Green
Maintain a high level of customer satisfaction, as measured by exceeding the most recently available federal government average rating of the Customer Satisfaction Index.	None	8ES13 Green	9ES20 Green	10ES16 Green	ES-11-18 Green
Uniform and Efficiency Measures					
	FY07	FY08	FY09	FY10	FY 2011
Complete all development projects within 110 percent of the cost and schedule baseline.	7ESS21 Yellow	8ES15 Yellow	9ES21 Red	10ES17 Red	ES-11-19 Red
Why NASA rated APG ES-11-19 Red: This annual performance goal was not met, due to cost and schedule growth that exceeded 10 percent of their estimated baseline for the NPOESS Preparatory Project (NPP), Glory and Aquarius missions. The NPP mission experienced delays due to the restructure of the project management and on-going development issues with an instrument, contributed by one of NASA's partners. The Aquarius mission was delayed by NASA's international partner, after the successful delivery of NASA's instrument contribution. The Glory mission had both instrument and spacecraft technical issues, across its development. (See page 176 for the Performance Improvement Plan.)					
Deliver at least 90 percent of scheduled operating hours for all operations and research facilities.	7ESS22 Green	8ES16 Yellow	9ES22 Green	10ES18 Green	ES-11-20 Green
Peer-review and competitively award at least 90 percent, by budget, of research projects.	7ESS23 Green	8ES17 Green	9ES23 Green	10ES19 Green	ES-11-21 Green
Reduce time within which 80 percent of NASA Research Announcement (NRA) research grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.	7ESS24 Red	8ES18 Green	9ES24 Red	10ES20 Yellow	ES-11-22 Yellow
Why NASA rated APG ES-11-22 Yellow: This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Earth Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 33 days, approximately 16 percent of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. (See page 172 for the Performance Improvement Plan.)					

Outcome 2.2

Understand the Sun and its interactions with Earth and the solar system.

Billions of years ago, at the core of the Sun, a nuclear furnace ignited. The energy the Sun provides, radiated almost constantly from its visible surface, is the basis of all advanced life on Earth. The Sun is a variable star, and its waxing and waning magnetic activity is the driver of space weather at Earth and across the solar system. Earth and the other planets reside in the extended atmosphere of the Sun. This extended atmosphere, called the heliosphere, comprises a plasma “soup” of electrified and magnetized matter entwined with penetrating radiation and energetic particles.

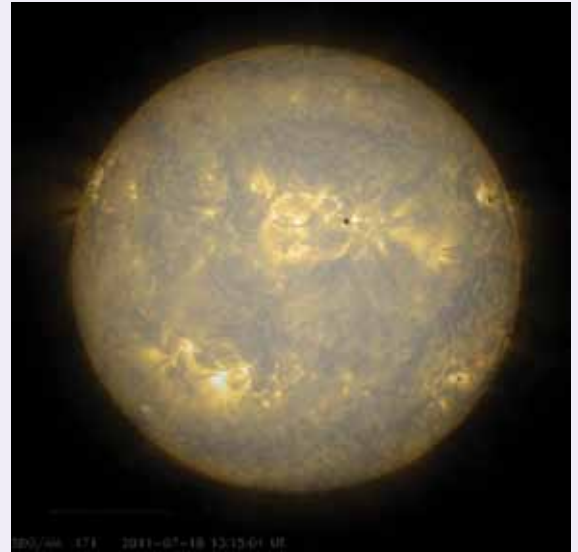
Heliophysics conducts missions that study the Sun, heliosphere, and planetary atmospheres as a single interconnected system. By analyzing these interconnections, scientists uncover fundamental physical processes that occur throughout the universe. These missions also improve capabilities for predicting the impacts of solar variability on human technological systems and safeguarding human and robotic space explorers outside the protective cocoon of Earth’s atmosphere.

NASA’s research in heliophysics has improved the understanding of space weather. NASA partners with the National Oceanic and Atmospheric Administration (NOAA) to serve the Nation’s need for reliable space weather information. NASA spacecraft, equipped with space weather beacons, provide real-time data to NOAA space weather forecasters. NASA cooperates with other agencies to enable new knowledge in this area and to measure conditions in space critical to both operations and scientific research.

NASA’s work to understand the causes and consequences of both short- and long-term changes in upper atmospheric density is important to satellite operators because atmospheric drag of these outermost layers significantly affects a satellite’s orbit. Sudden increases in this density can cause satellite orbits to drop unexpectedly, making them difficult to track. Understanding the relative contribution of the Sun and other drivers on the upper atmosphere will improve predictions of densities and temperatures that are critical to plan satellite lifetime and the time for replacement. The unprecedented low values seen in conjunction with lowest sunspot counts of 2009 had an effect much greater than anticipated and scientists are working hard to understand both the processes involved and their consequences for space operations, forecasting orbital tracks, and predicting the orbital lifetime and decay of both satellites and space debris.

Heliophysics completed three important mission milestones in FY 2011:

- The Science Mission Directorate (SMD) completed the Preliminary Design Review (PDR) for the Magnetospheric Multiscale’s (MMS’) mission operations center and science operations center on June 9, 2011. The PDR ensured that the designs and systems selected for the centers were appropriate to mission needs, the risks had been assessed, and the estimated cost and schedule baselines were acceptable. MMS will use Earth’s magnetosphere as a laboratory to study magnetic reconnection, a fundamental plasma-physical process that taps the energy stored in a magnetic field and converts it into heat and kinetic energy in the form of charged particle acceleration and large-scale flows of matter.
- A review team completed the Systems Integration Review (SIR) for the Radiation Belt Storm Probes (RBSP) on October 14, 2010. The SIR determined that all of RBSP’s systems were working together and were ready to be integrated into the spacecraft bus for testing. RBSP will help scientists better understand the Sun’s influence on Earth and near-Earth space by studying the planet’s radiation belts on various scales of space and time.



Sunspots, which are cooler, darker areas of intense magnetic activity, are most often the source of solar storms. On July 17 and 18, 2011, scientists using the Solar Dynamics Observatory (SDO) took observations of the Sun’s lower atmosphere in extreme ultraviolet light and of the surface in filtered light to see the correlation of the sunspots to the brighter active regions above the surface. The loops above the sunspot regions reveal magnetic field lines pushing out from the Sun. View [digital movies of this image](#). (Credit: SDO)

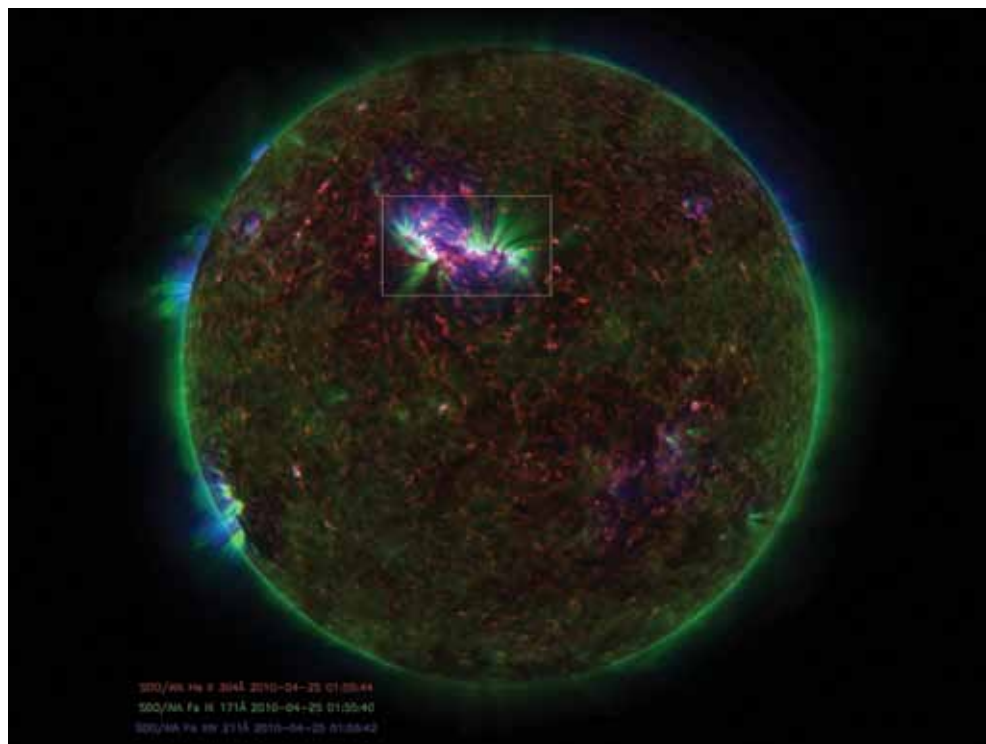
- The Interface Region Imaging Spectrograph (IRIS) mission completed its Critical Design Review (CDR) in February 2011, giving the project permission to begin final design and fabrication prior to the start of integration and testing. IRIS will resolve a fundamental challenge in heliophysics science by observing the Sun's chromosphere (the thin outer layer of gas) and transition region to understand how energy and plasma is transferred from the Sun into the solar wind.

Gaining a better understanding of fundamental physical processes of the space environment

New SDO observations yield vital clues about dynamic coronal heating

The plasma in the Sun's outer atmosphere (the corona) is mysteriously heated to millions of degrees, considerably hotter than the solar surface, or photosphere. Recent observations with NASA's Solar Dynamics Observatory (SDO) and a NASA instrument onboard the Japanese Hinode satellite have revealed how cool gas in the solar atmosphere is transferred into the corona while being heated to temperatures of millions of degrees, a pre-requisite for the formation of the solar wind. NASA is conducting this work as part of its objective to better understand fundamental physical processes of the space environment.

Cool gas in fountain-like jets, called spicules, are violently accelerated upward into the corona, with a small but significant fraction of the mass heated to much higher coronal temperatures. These results indicate that the Sun's chromosphere and corona are more tightly and dynamically coupled (transferring energetic particles between the two) than previously suspected. In fact, the corona itself may be populated and powered largely, if not entirely, by such energetic expulsions from the denser, cooler layers below. The physical process generally thought to drive these spicules is ultimately magnetic reconnection, a fundamental cause of magnetic energy release and reconfiguration throughout the heliosphere. Reconnection also is a prime suspect in triggering coronal mass ejections and heating their entrained plasma. ([Read more about this story.](#))



Spicules on the Sun jet off the surface of the Sun at 150,000 miles per hour. Research resulting from Hinode and SDO observations suggests that the spicules contain the gas that reaches temperatures over a million degrees, as observed in the solar corona. This composite SDO image, taken in various ultraviolet wavelengths, highlights resulting temperature differences in the million-degree corona. (Credit: NASA Goddard/SDO/AIA)

Identifying the driver of pulsating aurorae

Typical aurorae stretch more than 600 miles in length and last minutes at a time. Pulsating aurorae are small glowing patches of light only about 60 miles wide that flash on and off every 5 to 40 seconds. This flickering gives the appearance of exploding lights in the sky. Determining the cause of these pulsations has been a longstanding goal for over four decades. Using simultaneous aurora and spacecraft plasma wave observations, NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission has solved the mystery. When solar wind strikes Earth's

magnetic field, the wind induces electromagnetic waves in the near-space environment. A particular type of these waves, chorus, is able to interact with electrons in Earth's magnetic field, sending them downwards into the atmosphere and creating the pulsating aurora's light show much in the same way that a cathode ray tube creates images on the screens of older model televisions. NASA's THEMIS team discovered that these chorus waves appear at regular intervals in the same locations as the patches of light; the stronger the waves, the brighter the light. The data from THEMIS is helping NASA achieve its objective of improving understanding of the fundamental physical processes of the space environment from the Sun to Earth.

Observations of the lunar wake: refilling one of nature's natural vacuums

Heliophysics redirected two small satellites, originally launched into Earth orbit in 2007, into new orbits around the Moon to study the Moon's interactions with the solar wind. Both spacecraft were previously in an area called the Lagrangian points, or points on either side of the Moon where the Moon and Earth's gravity balance. This location is ideal for studying magnetism near the moon and how the solar wind—made up of ionized gas known as plasma—flows past the Moon and tries to fill in the vacuum on the other side.

The two spacecraft, together renamed the Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS) mission, have been making detailed observations of the Moon's plasma wake—a turbulent cavity carved out of the solar wind by the Moon itself, akin to the wake behind a speedboat. The Moon essentially is a non-magnetic, non-conducting obstacle in space that has no ionosphere. Solar wind plasma is absorbed on the Moon's dayside, leaving a plasma void on the night side. ARTEMIS scientists have discovered particle beams entering and refilling the lunar wake, along with plasma waves that occur in conjunction with these beams. This work will allow scientists to determine how the solar wind electrifies, alters, and erodes the surface of similar bodies in the solar system. ([Read more about this story.](#))

Space Shuttle plume motion demonstrates presence of unexpectedly high winds in the upper atmosphere

Space Shuttle and rocket launches burn many metric tons of liquid oxygen and liquid hydrogen as they ascend to orbit, generating extensive water vapor plumes in the upper atmosphere. The plumes can survive for several days and provide an important opportunity to trace upper atmospheric wind dynamics.

NASA's Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft recently documented the path of a Space Shuttle plume and observed unexpectedly intense and long-lasting upper atmospheric winds propelling the plume southward to the Antarctic peninsula. While the speed and scale of the movement was entirely unanticipated, the dynamics could be reproduced in models of the upper atmosphere. Scientists hypothesize that large-scale waves in atmospheric density and temperature are able to produce the measured wind speeds of nearly 80 miles per second. Such studies are important to understand the processes controlling the terrestrial upper atmosphere and provide an explanation for the relatively common occurrence of extreme winds in Earth's lower thermosphere, the second to last layer of Earth's atmosphere, where auroras occur and the International Space Station orbits.

Understanding how solar variability affects society, technology, and the habitability of other planets

New understanding of how radiation belt electrons are accelerated to their high energies

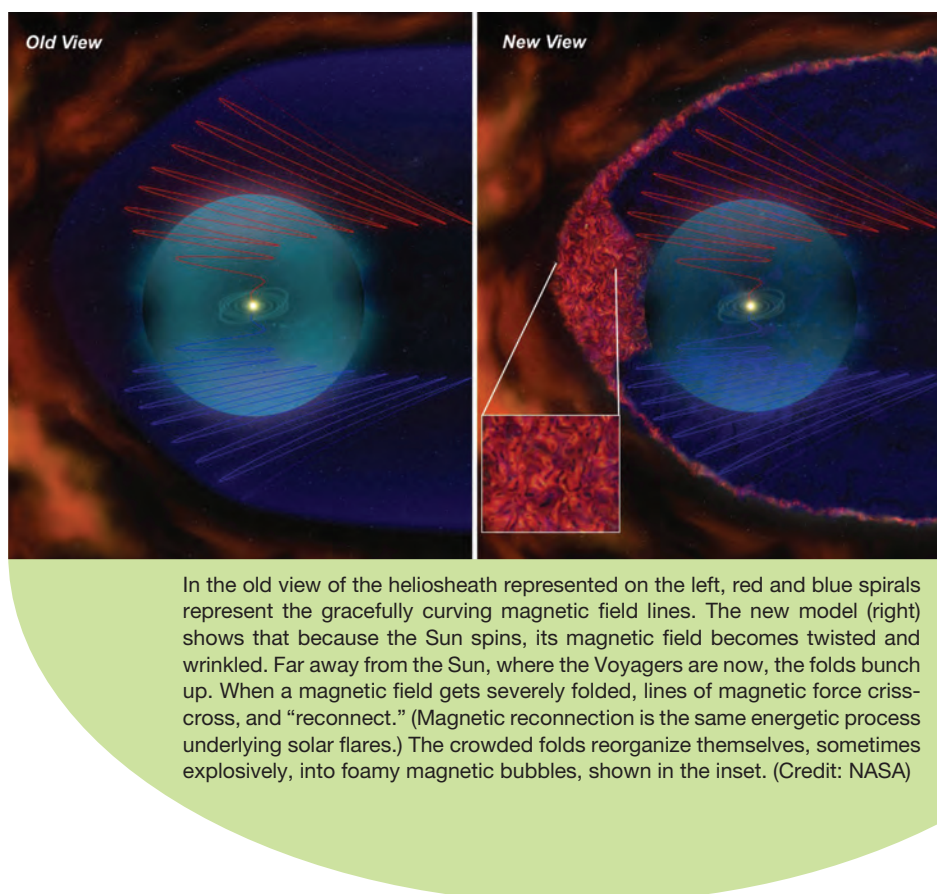
The Van Allen Radiation Belts (volumes of energetic charged particles, or plasma, held in place by Earth's magnetic field) are the most extreme radiation environment encountered by Earth-orbiting satellites. High-energy electrons in the outer radiation belt wreak havoc on satellite electronics, but just how these electrons are energized has been unclear. New NASA-funded studies using wave and particle measurements by the European Space Agency's Cluster mission have shed light on the initiation of this process: plasma waves generated by low-energy plasma in turn accelerate the relativistic electrons.

NASA's Wind spacecraft measurements have made the first detailed measurements of the acceleration process in the solar wind. Studying Wind observations provided the rare opportunity to examine this chain of physics in action, thus answering how waves are excited and can ultimately accelerate electrons to the relativistic energies such as observed in the radiation belts. The Radiation Belt Solar Probe (RBSP) mission, scheduled for launch in 2012, will provide the definitive measurements to understand radiation belt generation and degradation. Its data will help NASA achieve its objectives of better understanding the fundamental physical processes of the space environment and better understanding of human society and how life on Earth is affected by solar events.

Discoveries at the edge of the solar system

After 33 years of travel and traveling nearly one-million miles per day, the *Voyager-1* spacecraft has reached the outermost region of the heliosphere where the outward speed of the solar wind has slowed to zero. This indicates that the last boundary before entering interstellar space, the heliopause, is nearby. Scientists have used measurements taken by *Voyager-1* and its sister ship, *Voyager-2*, as they travel through the so-called heliosheath with theoretical modeling to create a completely new picture of this region, characterized as a “frothy mix” of magnetic bubbles produced by reconnection among the weak tendrils of the solar magnetic field. ([More on the Voyagers’ findings.](#))

Whereas the two *Voyager* spacecraft delivered two in-situ point measurements of the heliosheath, NASA’s [Interstellar Boundary Explorer \(IBEX\)](#) simultaneously produced a global picture from a near-Earth orbit, through images produced by energetic neutral atoms. Energetic neutral atoms of hydrogen are created where the solar wind interacts with the interstellar medium, both inside and beyond the heliosphere. Together, the *Voyager* and IBEX discoveries are stimulating a new quantitative understanding of how the heliosphere couples to interstellar space and the consequences of that interaction for the space ionizing radiation environment at Earth and elsewhere in the solar system. ([More on IBEX’s finds at the solar boundary.](#))



Earth’s near space environment is never truly quiescent

Though the last solar minimum was the quietest of the space age, there was still substantial activity in Earth’s near space environment. This activity differed in significant ways, however, from the activity associated with solar maximum conditions. Unlike solar maximum storms, which are driven largely by coronal mass ejections, during solar minimum corotating interaction regions (CIRs), high-speed streams in the solar wind that recur each solar rotation, are the primary contributor to the recurrent geomagnetic activity at Earth. Even during the calmest of solar conditions, these CIRs can drive substantial density changes in the upper atmosphere. Observations from the German [Challenging Mini-Satellite Payload \(CHAMP\)](#) satellite have shown that the thermosphere density responds to high-speed streams globally, and the density at 249 mile (400 kilometer) altitude changes by 75 percent on average. CIRs also can trigger substorms and particle acceleration in geospace, changing the configuration of the inner magnetospheric ring current. The [Two Wide-angle Imaging Neutral-atom Spectrometers \(TWINS\)](#) observations of numerous solar minimum CIR-driven storms have shown some significant and interesting differences from coronal mass ejection-driven storms and demonstrated that during the post-storm recovery, the global ring current energy density falls much more rapidly than would be expected based on ground-based magnetometer measurements.

Improved space weather prediction—from a phone

A few hours before a gigantic bubble of electrified gas and charged particles erupted from the Sun, NASA officially released the new Space Weather App, making images and other data almost immediately available to users.

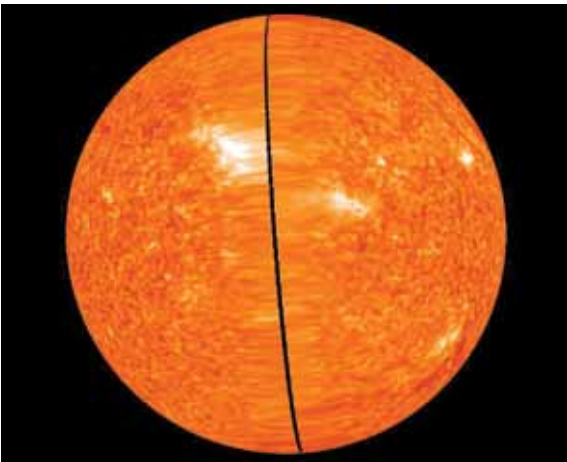
A fast-moving mass ejection from the Sun raced through space at 1,242 miles per second, and while it did not strike Earth directly, the eruption did trigger a run at the iTunes store. Within just a couple of days, 1,500 users had already downloaded the application, making it one of the store's 20 most popular in the weather category. ([Read more about the Space Weather App.](#))

First-ever images of the entire Sun reveal that activity can involve much more than is visible from Earth

On February 6, NASA's twin [STEREO spacecraft](#) moved into position on opposite sides of the Sun. They are now beaming down images which, combined with those from the Earth-orbiting SDO, show the entire solar sphere—front and back—without interruptions. This unprecedented view has revealed connections previously unseen and helping NASA researchers better predict extreme and dynamic conditions in space.

Researchers long suspected that solar activity can “go global,” with eruptions on opposite sides of the Sun triggering and feeding off of one another. Now they have actually studied the phenomenon. The [Great Eruption of August 2010](#) engulfed about two thirds of the solar surface with dozens of mutually interacting flares, shock waves, and reverberating filaments. Much of the action was visible from Earth’s perspective, including SDO, but some was hidden behind the limb (where the curve of Earth meets the blackness of space) and only visible to the STEREO spacecraft looking at the Sun from different angles.

Studies of these coupled phenomena provide warnings of solar active regions producing flares, coronal mass ejections, and energetic particles before they are visible from Earth. The global solar view also yields space weather situational awareness throughout the solar system. For example, STEREO observations from the far side of the Sun provided warning of a coronal mass ejection that struck NASA’s [MESSENGER spacecraft](#) a glancing blow as it was being inserted into orbit around the planet Mercury.



This image, taken February 2, 2011, of the far side of the Sun based on STEREO data, still shows a small gap between the STEREO Ahead and Behind data. On February 6, the spacecraft achieved 180-degree separation, closing the gap. (Credit: NASA)

Space Weather Shock Forecasts

In partnership with NOAA, NASA has developed a computer program to provide near real-time identification of interplanetary shocks waves created by coronal mass ejections from the Sun. Interplanetary shocks are known to be major drivers of geomagnetic storms. The new computer program automatically searches magnetic field and solar wind data from NASA’s [Advanced Composition Explorer \(ACE\)](#) to provide advanced warning for the arrival of interplanetary shocks at Earth. In some cases, the shock conditions can be identified within ten minutes after the solar wind plasma impacts the ACE spacecraft, which is located upstream of the solar wind between the Sun and Earth. As a result of this improved shock detection method, space weather forecasters can now better utilize the 15 to 45 minutes of advance warning prior to the shock’s collision with Earth’s magnetopause. This work provides a significant improvement from previous forecast models.

Outcome 2.2					
Understand the Sun and its interactions with Earth and the solar system.					
					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.2.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS13 Green	8HE01 Green	9HE1 Green	10HE01 Green	HE-11-1 Green

FY 2011 Performance Goal					FY 2011
By 2015, launch two missions in support of this outcome.					2.2.1.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Magnetospheric MultiScale (MMS) Mission Operations Center and Science Operations Center Preliminary Design Review.	7ESS15 Red	8HE02 Green	9HE2 Green	10HE02 Green	HE-11-2 Green
Complete the Geospace Radiation Belt Storm Probes Systems Integration Review.	7ESS16 Green	8HE04 Green	9HE3 Green	10HE03 Green	HE-11-3 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.2.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding how human society, technological systems, and the habitability of planets are affected by solar variability interacting with planetary magnetic fields and atmospheres. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS19 Green	8HE03 Green	9HE6 Green	10HE06 Green	HE-11-4 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch two missions in support of this outcome.					2.2.2.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Magnetospheric MultiScale (MMS) Mission Operations Center and Science Operations Center Preliminary Design Review.	7ESS15 Red	8HE02 Green	9HE2 Green	10HE02 Green	HE-11-2 Green
Complete the Geospace Radiation Belt Storm Probes Systems Integration Review.	7ESS16 Green	8HE04 Green	9HE3 Green	10HE03 Green	HE-11-3 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.2.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in maximizing the safety and productivity of human and robotic explorers by developing the capability to predict the extreme and dynamic conditions in space. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7ESS20 Green	8HE05 Green	9HE8 Green	10HE08 Green	HE-11-5 Green
FY 2011 Performance Goal					FY 2011
By 2017, launch at least two missions in support of this outcome.					2.2.3.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the Geospace Radiation Belt Storm Probes Systems Integration Review.	7ESS16 Green	8HE04 Green	9HE3 Green	10HE03 Green	HE-11-3 Green
Uniform and Efficiency Measures					
	FY07	FY08	FY09	FY10	FY 2011
Complete all development projects within 110 percent of the cost and schedule baseline.	7ESS21 Yellow	8HE07 Red	9HE10 Yellow	10HE09 Red	HE-11-6 White
Why NASA rated APG HE-11-6 White: The metric indicates the final development costs, once a mission launches, but there were no planned launches for FY 2011 in Heliophysics. Hence the measure is not applicable to this fiscal year, and rated white..					
Deliver at least 90 percent of scheduled operating hours for all operations and research facilities.	7ESS22 Green	8HE08 Green	9HE11 Green	None	HE-11-7 Green
Peer-review and competitively award at least 90 percent, by budget, of research projects.	7ESS22 Green	8HE09 Green	9HE12 Green	None	HE-11-8 Green
Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.	7ESS24 Red	8HE10 Yellow	9HE13 Green	10HE12 Red	HE-11-9 Green

Outcome 2.3

Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

Planetary Science's missions have revolutionized understanding of the origin and history of the solar system. NASA has missions circling the innermost planet, Mercury, and heading for the outer reaches of the solar system, where Pluto orbits among many Kuiper Belt objects. Its missions have orbited and roved the surface of Mars, finding evidence of liquid water. Closer to home, Planetary Science uses ground-based sensors in coordination with the National Science Foundation and the U.S. Air Force to survey the volume of near-Earth space to detect, track, catalog, and characterize near-Earth objects that may either pose hazards to Earth or provide destinations and resources for future exploration.

NASA's robotic science missions are paving the way for understanding the origin and evolution of the solar system and identifying past and present habitable locations. With this knowledge, NASA is enabling human space exploration by studying and characterizing planetary environments beyond Earth and identifying possible resources that will enable safe and effective human missions to destinations beyond low Earth orbit.

Robotic explorers gather data to help scientists understand how the planets formed, what triggered different evolutionary paths among planets, what processes are active, and how Earth formed, evolved, and became habitable. To search for evidence of life beyond Earth, scientists use this data to map zones of habitability, study the chemistry of unfamiliar worlds, and unveil the processes that lead to conditions necessary for life.

Planetary Science completed some important milestones this fiscal year:

- In August 2011, NASA completed the Juno Launch Readiness Review, the last review of the spacecraft, its launch vehicle, and launch systems. The mission launched on August 5, beginning its five-year journey to Jupiter. At the end of the month, the mission team began checking the spacecraft's camera by taking images of Earth and the Moon ([for more information, go to the news release](#)). Planetary Science completed Juno development within the lifecycle estimate for both cost and schedule.
- NASA completed the Gravity Recovery and Interior Laboratory (GRAIL) mission Pre-Ship Review on May 5, 2011. This review was a quality check conducted before the two spacecraft were shipped from the contractor that built them to NASA for launch preparations. On September 10, GRAIL launched on its way to the Moon to begin mapping lunar gravity and using that information to increase understanding of the Moon's interior and thermal history. Planetary Science completed GRAIL development within the estimated life cycle for both cost and schedule.
- NASA completed the Confirmation Review for the Mars Atmosphere and Volatile Evolution Mission (MAVEN) on October 4, 2010. This review determined that the project team had successfully formulated a plan that established the project purpose, scope, parameters, deliverables, and providers, assessed risk, and estimated a lifecycle cost and schedule that covered these elements. With the review completed, MAVEN entered development, when the spacecraft is built and tested. In July, MAVEN passed another critical milestone when an independent review board, composed of reviewers from NASA and several external organizations, met to validate the



As the Sun comes up over Cape Canaveral Air Force Station in Florida on August 5, 2011, preparations are under way at Space Launch Complex 41 to launch the Atlas V-551 launch vehicle carrying NASA's Juno spacecraft. (Credit: NASA/K. Allen)

system design as part of the Critical Design Review. This review granted permission to the mission team to begin manufacturing hardware. MAVEN will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses.

- The Jet Propulsion Laboratory completed the Mars Science Laboratory (MSL) Pre-Ship Review on May 5, 2011, and pressed ahead with launch preparation activities. System testing put the rover and other parts of the spacecraft through simulations of many activities from launch through operations on Mars' surface.

Below is a sample of FY 2011 activities that supported this outcome.

Understanding the formation, evolution, and behavior of solar system objects

WISE has a second career hunting for asteroids

While the Wide-field Infrared Survey Explorer (WISE), launched in December 2009, was performing its prime mission—scanning the entire sky to build a detailed map in the infrared—its tens of thousands of images were also being examined to find objects in our own solar system. It proved to be particularly useful for finding near Earth objects (NEOs), asteroids and comets with orbits that come within 28 million miles of Earth's path around the Sun and that may pose an impact hazard. This "NEOWISE" project of the WISE mission was dedicated to hunting for asteroids and comets. In early October 2010, WISE ran out of the coolant that keeps its instrumentation cold, but two of its four infrared detectors remained operational, and these two channels were used to complete the one year entire scan around the solar system.

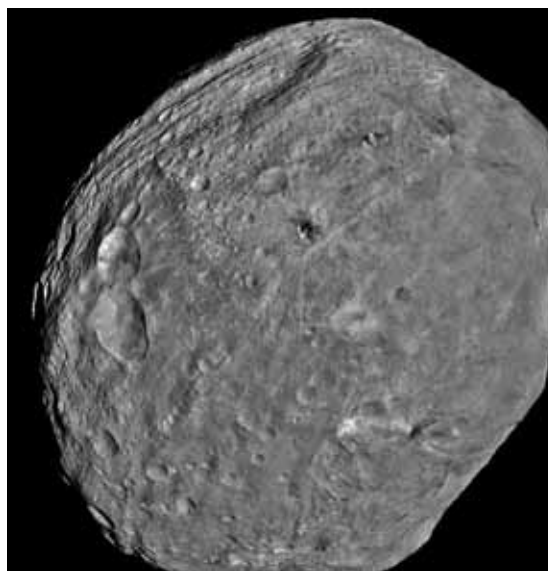
By the end of survey operations in February 2011, the NEOWISE researchers observed over 157,000 asteroids, including more than 585 NEOs, and 120 comets. The mission's discoveries of previously unknown objects include 20 comets, more than 33,000 asteroids in the main belt between Mars and Jupiter, and 134 NEOs. NEOWISE also observed objects farther away than the main belt: about 2,000 asteroids that orbit ahead and behind Jupiter, the so-called Trojan asteroids.

These observations will be key to determining the objects' sizes and compositions. Visible-light data reveals only how much sunlight reflects off an asteroid, but infrared data is directly related to the object's size and provides much more accurate estimates. By combining visible and infrared measurements, astronomers also can learn more about the size and compositions of the rocky bodies, for example, whether they might be solid or crumbly. The findings will lead to a much-improved picture of the various asteroid populations.

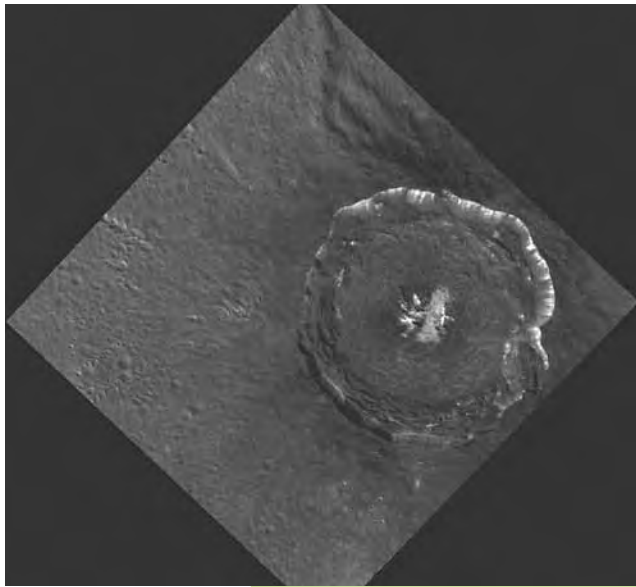
Dawn enters into orbit around Vesta

The Dawn spacecraft, after a 1.7 billion mile journey, slipped into orbit around Vesta on July 15, starting a yearlong science campaign to map one of the solar system's largest asteroids. Images taken in the High-Altitude Mapping Orbit show that the surface of Vesta appears to be much rougher than other asteroids in the main asteroid belt. Preliminary dates from a method that uses the number of craters indicate that areas in the southern hemisphere are as young as 1 to 2 billion years old, much younger than areas in the north. One spectacular image shows a mountain three times as high as Mt. Everest, amidst the topography in the south polar region, rising about 13 miles (22 kilometers) above the average height of the surrounding terrain, making it one of the tallest mountains in the solar system. Dawn is the first spacecraft to enter orbit around a main asteroid belt object, use an ion engine on a NASA planetary mission, and visit an asteroid thought to be the source of many meteorites found here on Earth. ([Read more about Dawn arriving at Vesta.](#))

Dawn's goal is to characterize the conditions and processes of the solar system's earliest epoch by investigating in detail two of the largest asteroids hypothesized to once have been protoplanets remaining intact since their formation: Vesta and Ceres. Protoplanets were small bodies that collided to gradually form dominant planets during the early development of a solar system. Dawn is investigating Ceres and Vesta to learn more about the evolutionary paths they followed.



On July 24, 2011, NASA's Dawn spacecraft obtained this image, taken from a distance of about 3,200 miles, of the giant asteroid Vesta with its framing camera. Dawn entered orbit around Vesta on July 15 and will spend a year orbiting the body. After that, the next stop on its itinerary will be an encounter with the dwarf planet Ceres. (Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)



This MESSENGER image, acquired in May 2011, provides an extraordinary view of the crater Degas on Mercury. The crater's floor contains cracks that formed as the pool of impact melt cooled and shrank. The high-reflectance material on the walls and in the central portion of the crater probably has a composition distinct from that of the crater floor and surroundings. The illumination conditions and down-slope movement of eroded material exposing fresh rock also contributed to the bright appearance. (Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington)

Understanding the origin and evolution of the solar system's planets, moons, and bodies

MESSENGER reaches Mercury orbit insertion and begins orbital observations

MESSENGER ([Mercury Surface, Space Environment, Geochemistry and Ranging](#)), the first spacecraft to orbit Mercury, reached orbit insertion at the solar system's innermost planet on March 17, 2011, and sent its first image from orbit on the 29th, beginning the first up-close study of the smallest planet.

MESSENGER will map the entire surface of Mercury and monitor changes in the planet's atmosphere. Mercury is one of four terrestrial (rocky) planets in the solar system, along with Earth, Venus, and Mars. Among these four, it is a planet of extremes: it is the smallest, the densest, the one with the largest daily variations in surface temperatures, the one with the oldest surface, and the least explored. Understanding this extreme terrestrial planet is key to understanding how the planets in the solar system formed and evolved.

Scientists are discovering that many previous theories based on earlier flybys by MESSENGER and by [Mariner 10](#) in the 1970s must now be revisited due to results coming in from MESSENGER's orbital observations. Exciting new results include evidence that Mercury may have experienced explosive volcanic activity in its past on a global scale and images showing a new class of features called "hollows," fresh-appearing, irregular, shallow, rimless depressions. (See [the September 30, 2011, issue of *Science*](#) for more on these results.)

Juno on a mission to discover the origin of the solar system

On August 5, 2011, NASA launched the [Juno spacecraft](#) on its mission to study the solar system's largest planet, Jupiter. Underneath this gas giant's dense cloud cover are secrets to the fundamental processes and conditions that governed the solar system during its formation. Theories about solar system formation all begin with the collapse of a giant cloud of gas and dust, or nebula, most of which formed the infant Sun. Like the Sun, Jupiter is mostly hydrogen and helium, so it likely formed early, capturing material left after the Sun was born. Scientists have posed different scenarios for how this may have happened: a massive planetary core formed first and gravitationally captured gas, or an unstable region collapsed inside the nebula, triggering the planet's formation. Juno may provide the data needed to understand how the solar system formed.

As the primary example of a giant planet, Jupiter also can provide critical knowledge for understanding the planetary systems being discovered around other stars, which frequently have one or more one or more Jupiter-sized or super-Jupiter planets. With its suite of science instruments, Juno will investigate the existence of a solid planetary core, map Jupiter's intense magnetic field, measure the amount of water and ammonia in the deep atmosphere, and observe the planet's auroras.

Water, discovered in lunar rocks, raises questions about origin of the Moon

In May 2011, a team of NASA-funded researchers published their findings that they measured, for the first time, water from the Moon contained in tiny globules of molten rock, which have turned to glass-like material trapped within crystals. Data from these lunar melt inclusions indicate the water content of lunar magma was 100 times higher than previous studies suggested, and confirm that the Moon is not as dry as previously thought. The higher water content has implications for the origin of the Moon and may shed light on how the inner planets acquired their water.

The inclusions were found in a sample collected during the [Apollo 17 mission](#) in 1972. The scientific team used a state-of-the-art ion microprobe instrument to measure the water content of the inclusions contained within the famous “orange glass soil” formed during explosive eruptions about a 3.7 billion years ago.

The results raise questions about aspects of the “giant impact theory” of how the Moon was created. That theory predicted that a catastrophic collision between Earth and a Mars-sized body very early in Earth’s history would have produced a Moon with very low water content. The energetic collision would have stripped away volatiles, “degassing” the resultant early Moon. The team’s work, however, shows that at least parts of the lunar interior had as much water as parts of Earth’s current interior. The study also puts a new twist on the origin of water-ice detected in craters at the lunar poles by several recent NASA missions, including the [Lunar Reconnaissance Orbiter \(LRO\)](#) and the [Lunar Crater Observation and Sensing Satellite \(LCROSS\)](#). The ice has been attributed to comet and asteroid impacts, but the researchers think it is possible that some of the ice came from water released by the eruption of lunar magmas eons ago. ([Read more on the lunar water study.](#))

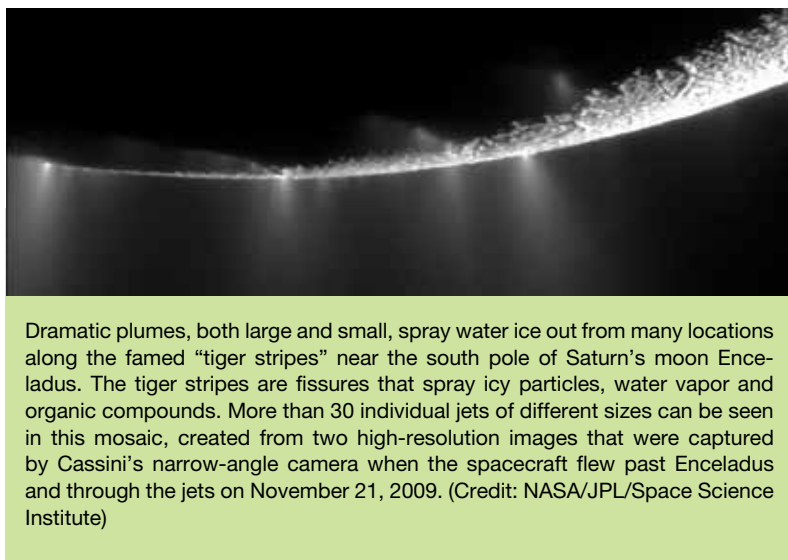
Discovering the history and habitability of Mars and other solar system bodies

Enceladus’ ocean-like spray indicates salt water reservoir

NASA’s [Cassini spacecraft](#) has discovered the best evidence yet for a large-scale salt-water reservoir beneath the icy crust of Saturn’s moon Enceladus. The data came from the spacecraft’s direct analysis of salt-rich ice grains close to the jets ejected from the moon.

The discovery of plumes of water vapor and ice particles from warm fractures, known as tiger stripes, raised the question of whether the plumes were emerging from a subsurface liquid source or from the decomposition of ice. New analysis from Cassini’s cosmic dust analyzer instrument, and published in the [June issue of *Nature*](#), found that relatively large grains rich with sodium and potassium dominate the plumes. The salt-rich particles have an “ocean-like” composition that indicate that most, if not all, of the expelled ice and water vapor comes from the evaporation of liquid salt water.

This analysis suggests a layer of water between the moon’s rocky core and its icy mantle, possibly as deep as about 50 miles beneath the surface. As this water washes against the rocks, it dissolves salt compounds and rises through fractures in the overlying ice to form reserves nearer the surface. If the outermost layer cracks open, the decrease in pressure from these reserves to space causes a plume to shoot out. The authors suggest the water reserves must have large evaporating surfaces, or they would freeze easily and stop the plumes. Liquid water is one of the prerequisites for known forms of life, making Enceladus another target of interest for studies of past or current habitability. ([Read more on this story.](#))



Landing site selected for upcoming Mars mission

On June 22, 2011, NASA announced Gale crater as the landing site for the [Mars Science Laboratory’s \(MSL’s\)](#) car-sized rover, [Curiosity](#). This was one of the important last milestones for preparing the mission for launch, achieving half of the requirements for Performance Goal 2.3.3.2. About the combined area of Connecticut and Rhode Island, Gale crater offers diverse stratigraphy (or rock layering), including possible water-bearing materials like sulfates and phyllosilicates, that suggests it is the surviving remnant of an extensive sequence of deposits. ([Read more about the site selection.](#))

NASA is preparing MSL for launch during the first quarter of FY 2012. In a prime mission lasting one Martian year (nearly two Earth years), researchers will use the rover's tools to study whether the landing region has had environmental conditions favorable for supporting microbial life and for preserving clues about whether life existed.

Study Earth to determine if there is or ever has been life elsewhere in the universe

More asteroids could have made life's ingredients

A wider range of asteroids was capable of creating the kind of amino acids used by life on Earth, according to NASA Astrobiology Institute (NAI)-funded researchers.

In 2009, the team from the [Goddard Center for Astrobiology](#) reported the discovery of an excess of the left-handed form of the amino acid, isovaline, in samples of meteorites that came from carbon-rich asteroids. In a paper published in the December 2010 issue of *Meteoritics and Planetary Science*, the team reports finding excess left-handed isovaline (L-isovaline) in a much wider variety of carbon-rich meteorites. Amino acid molecules can be built in two ways that are mirror images of each other. Life on Earth uses left-handed amino acids, and they are never mixed with right-handed ones, but the amino acids found in the meteorite had equal amounts of the left and right-handed varieties.

Researchers recovered the asteroid remnants, collectively called Almahata Sitta, in the Sudanese desert in 2008, an example of ureilite meteorites (a rare, stony meteorite that has a high percentage of carbon in the form of graphite and nanodiamonds) found in pristine condition. A sample was divided between the [Goddard Space Flight Center](#) and a laboratory at the [Scripps Institution of Oceanography](#) at the University of California, San Diego. The extremely sensitive equipment in both labs detected small amounts of 19 different amino acids in the sample, ranging from 0.5 to 149 parts per billion. The authors suggest that the amino acids may have formed through reactions in gases as the very hot asteroid cooled down. The team had to be sure that the amino acids in the meteorite did not come from contamination by life on Earth.

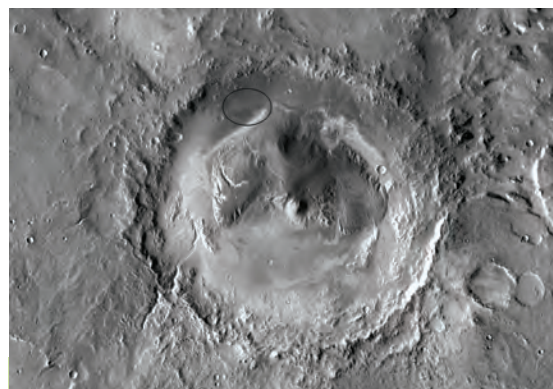
Amino acids are used to make proteins, the workhorse molecules of life, used in everything from structures like hair to enzymes, the catalysts that speed up or regulate chemical reactions. Life uses 20 different amino acids in a huge variety of arrangements to build millions of different proteins. Some researchers hypothesize that ureilite meteorites were formed in the solar nebula, suggesting that the amino acids found in the Almahata Sitta samples might have been synthesized very early in the history of the solar system. (Read more on [this story](#).)

A bacterium that can grow by using arsenic instead of phosphorus

Life uses a combination of the elements carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Other elements may be present, but these six are the most common and essential for biological molecules.

NASA-funded researchers conducting tests in the harsh environment of Mono Lake, California, discovered the first known microorganism on Earth able to thrive and reproduce using the normally toxic chemical arsenic in place of phosphorus. Phosphorus is a central component of the energy-carrying molecule in all cells and also the phospholipids that form all cell membranes. Arsenic, which is chemically similar to phosphorus, disrupts metabolic pathways because chemically it behaves like phosphate.

The results of this study will inform ongoing research in many areas, including the study of Earth's evolution, organic chemistry, biogeochemical cycles, disease mitigation and Earth system research. They also will open new frontiers in microbiology and other disciplines. (Read more about [this study](#).)



The ellipse superimposed on this image of Gale crater indicates the intended landing area for the MSL rover, *Curiosity*. The portion of the crater within the landing area has an alluvial fan likely formed by water-carried sediments. The lower layers of the nearby mountain—within driving distance for *Curiosity*—contain minerals indicating a wet history. (Credit: NASA/JPL-Caltech/ASU)

Identify and learn about small solar system bodies

Finding near Earth objects

NASA and its partners maintain a watch for near-Earth objects, asteroids and comets that pass close to Earth, as part of an ongoing effort to discover, catalog, and characterize these potentially hazardous objects. This fiscal year, asteroid search teams funded by NASA's [Near Earth Object Observation Program](#) found another twelve asteroids larger than one kilometer, or 0.62 miles, in size with orbits coming within Earth's vicinity.

Near-Earth objects pose a threat to property, the environment, and even life itself. Near-Earth objects that are one kilometer in diameter or larger pose the biggest overall hazard, because if they do impact it would have global consequences, including ejected debris spread around the Earth and into its atmosphere, blocking sunlight for many months to years. Smaller objects pose a more frequent hazard because with their much greater numbers they are the most likely to impact Earth. All of these objects hold great scientific interest because they represent relatively unchanged debris from the solar system formation process some 4.6 billion years ago. They may carry with them ice and the building blocks of life. NASA funds teams that detect and catalogue near-Earth objects for both planetary protection and scientific purposes.

Asteroid search teams also found one more near Earth comet and 959 smaller asteroids of less than one kilometer in average diameter, bringing the total number known of all sizes to 8,294. The high precision orbit predictions computed by NASA's [Jet Propulsion Laboratory](#) show that none of these objects are likely to hit Earth in the next century. However, 1,250 (of which 150 are larger than one kilometer in diameter) are in orbits that could become a hazard in the more distant future and warrant continued monitoring.

The results of the NEOWISE project, discussed earlier, complete and confirm the achievement this year of the initial "Spaceguard" goal, set with Congress back in 1998, to find at least 90 percent of the one kilometer and larger NEOs. NEOWISE analysis shows our search teams have now found 911 (+17) of 981 (+19), or 93 percent of the one kilometer and larger population ([see story here](#)).

NASA selects New Frontiers 3 mission—OSIRIS-REx

In May 2011, [Planetary Science](#) selected an asteroid sample return as the third mission for its [New Frontiers Program](#) of solar system explorations. The Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer, or OSIRIS-REx, will be the first U.S. mission to retrieve and carry materials from an asteroid back to Earth. Planned for launch in 2016, the spacecraft will use a robotic arm to collect samples that could better explain the solar system's formation and how life began.

Asteroids are leftovers formed from the cloud of gas and dust—the solar nebula—that collapsed to form the Sun and the planets about 4.6 billion years ago. As such, they contain the original material from the solar nebula, which can tell scientists about the conditions of the solar system's birth.

After rendezvous and acquisition of a sample, OSIRIS-REx will store the material in a capsule to be returned to Earth in 2023. The capsule's design will be similar to that used by NASA's [Stardust spacecraft](#), which returned the world's first comet particles from comet Wild 2 in 2006. (Read more about the [mission selection](#).)

Outcome 2.3					
Ascertain the content, origin, and evolution of the solar system and the potential life elsewhere.					
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.3.1.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in inventorying solar system objects and identifying the processes active in and among them. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	None	None	None	None	PS-11-1 Green
Achieve arrival of Dawn at Vesta.	None	None	None	None	PS-11-2 Green
FY 2011 Performance Goal					FY 2011
By 2017, launch at least two missions in support of this outcome.					2.3.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the mission concept studies for the New Frontiers 3 mission.	None	None	None	10PS04 Green	PS-11-3 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.3.2.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding how the Sun's family of planets, satellites, and minor bodies originated and evolved. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7SSE1 Green	8PS01 Green	9PS1 Green	10PS01 Green	PS-11-4 Green
Complete the MESSENGER Mercury Orbit Insertion.	7SSE1 Green	8PS02 Green	None	None	PS-11-5 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch at least three missions in support of this outcome.					2.3.2.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the mission concept studies for the New Frontiers 3 mission.	None	None	None	10PS04 Green	PS-11-3 Green
Complete the Juno Launch Readiness Review.	7SSE3 White	8PS03 Green	9PS2 Green	10PS02 Green	PS-11-6 Green
Complete the Gravity Recovery and Interior Laboratory (GRAIL) Pre-Ship Review.	None	None	9PS3 Green	10PS03 Green	PS-11-7 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.3.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding the processes that determine the history and future of habitability of environments on Mars and other solar system bodies. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7SSE6 Green	8PS06 Green	9PS8 Green	10PS09 Green	PS-11-8 Green
FY 2011 Performance Goal					FY 2011
By 2015, launch at least two missions in support of this outcome.					2.3.3.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Mars Atmosphere and Volatile Evolution Mission (MAVEN) Confirmation Review.	None	None	None	10PS08 Green	PS-11-10 Green
Complete the Mars Science Laboratory (MSL) Pre-Ship Review.	7SSE5 Green	8PS05 Green	9PS4 Red	10PS06 Yellow	PS-11-9 Green

FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.3.4.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding the origin and evolution of life on Earth and throughout the biosphere to determine if there is or ever has been life elsewhere in the universe. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7SSE4 Green	8PS04 Green	9PS5 Green	10PS07 Green	PS-11-11 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.3.5.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in identifying and characterizing small bodies and the properties of planetary environments that pose a threat to terrestrial life or exploration or provide potentially exploitable resources. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7SSE8 Green	8PS08 Green	9PS9 Green	10PS10 Green	PS-11-12 Green
FY 2011 Performance Goal					FY 2011
Return data for selection of destinations in order to lower risk for human space exploration beyond low Earth orbit.					2.3.5.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop an archive of high resolution images of the moon from the Lunar Reconnaissance Orbiter (LRO) necessary for human space exploration to determine potential landing sites.	None	None	9AC16 Green	10AC17 Green	PS-11-13 Green
Uniform and Efficiency Measures					
	FY07	FY08	FY09	FY10	FY 2011
Complete all development projects within 110 percent of the cost and schedule baseline.	7SSE10 Red	8PS09 White	9PS11 Red	10PS15 White	PS-11-14 Green
Deliver at least 90 percent of scheduled operating hours for all operations and research facilities.	7SSE11 Green	8PS10 Green	9PS12 Green	10PS16 Green	PS-11-15 Green
Peer-review and competitively award at least 95 percent, by budget, of research projects.	7SSE12 Green	8PS11 Green	9PS13 Green	10PS13 Green	PS-11-16 Green
Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.	7SSE13 Red	8PS12 Green	9PS14 Green	10PS14 Red	PS-11-17 Red
Why NASA rated Uniform and Efficiency Measure PS-11-17 Red: This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Planetary Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 76 days, approximately 35 percent of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. It is estimated that without the impact of the Continuing Resolution, the Planetary Science Division would have missed its target regardless. Other factors contributing to the missed target included staffing transitions in positions key to this process during FY 2011 (new Research & Analysis Lead and new program scientists). The involvement of these scientists in critical mission activities for multiple 2011 launches (Juno, GRAIL, MSL), as well as multiple FY 2011 Announcements of Opportunity also prevented improvement. (See page 173 for the Performance Improvement Plan.)					

Outcome 2.4

Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.

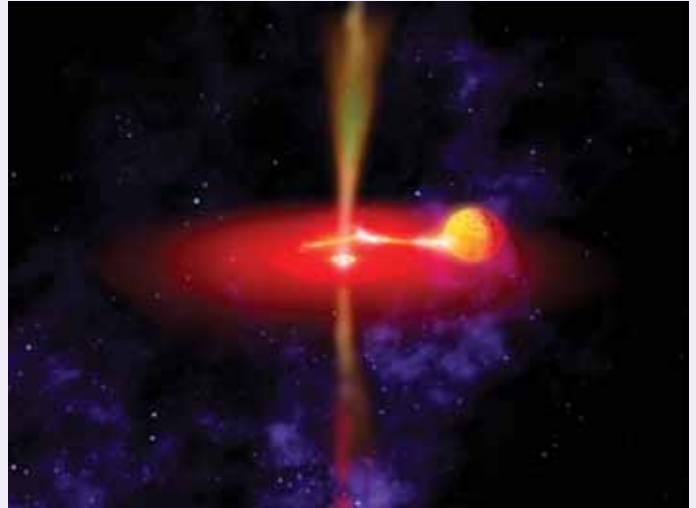
The Astrophysics theme seeks to understand the birth of the universe, the edges of space and time near black holes, and the dark energy that fills the entire universe. It is exploring the relationship between the smallest of sub-atomic particles and the vast expanse of the cosmos. Its missions reveal the diversity of planets and planetary system architectures in the Milky Way galaxy, pinpoint Earth-like, potentially life-supporting planets in other solar systems, and study stellar and planetary environments and what powers the most energetic galaxies. Astrophysics designs and launches space telescopes that work in conjunction with other ground and airborne telescopes to exploit the full range of the electromagnetic spectrum to view the broad diversity of the objects in the universe.

NASA's Astrophysics missions have provided researchers with new ways of looking at the universe so that they can expand knowledge about cosmic origins and fundamental physics. The study of the universe benefits the Nation's scientific research community by focusing research and advanced technology developments on optics, sensors, guidance systems, and propulsion systems. Some of these new and improved technologies enable ground-breaking capabilities, which are then available to both the commercial and defense sectors.

Stunning images produced from Astrophysics' operating missions continue to inspire the public, revealing the beauty of the universe and the science behind those images. The striking images from these observatories also are educational tools to help spark student interest in science, technology, engineering, and mathematics and serve to prominently illustrate the role of the United States in scientific exploration. NASA provides the tools to translate the science for the classroom and other learning venues in ways that meet educator needs.

Astrophysics completed two major milestones during the fiscal year:

- NASA completed the System Integration Review (SIR) for the Nuclear Spectroscopic Telescope Array (NuSTAR) mission on January 28, 2011. The SIR evaluated the readiness of the project to start flight system assembly, test, and launch operations. NuSTAR will use high energy X-rays to search for black holes, map supernova explosions, and study the most extreme active galaxies.
- In September 2011, NASA's Program Management Council approved a rebaseline for the James Webb Space Telescope (JWST). This is the program's first major step in realigning cost and schedule commitments based on recent assessments of its planned science goals, technology readiness levels, progress to date, and risks. JWST, which entered development in July 2008, will use the infrared spectrum to observe the highly red-shifted early universe, where cool objects like protostars and protoplanetary disks emit strongly and dust obscures shorter wavelengths.



Astronomers using NASA's Wide-field Infrared Survey Explorer (WISE) have captured rare data of a flaring black hole, revealing new details about these powerful objects and their blazing jets. This artist's concept illustrates what the flaring black hole called GX 339-4 might look like. Infrared observations from WISE reveal the best information yet on the chaotic and extreme environments of this black hole's jets. GX 339-4 likely formed from a star that exploded. It is surrounded by an accretion disk (red) of material being pulled onto the black hole from a neighboring star (yellow orb). Some of this material is shot away in the form of jets (yellow flows above and below the disk). The region close in to the black hole glows brightly in infrared light. [Read more about this story.](#) (Credit: NASA)

Understanding black holes, dark energy, dark matter, and their relationship to the origin of the universe

Dark energy is accelerating the expansion of the universe

A five-year survey of 200,000 galaxies using the [Galaxy Evolution Explorer \(GALEX\)](#) space telescope, stretching back seven billion years in cosmic time, has led to one of the best independent confirmations that dark energy is driving the universe apart at accelerating speeds. Astronomers think that the expansion of the universe is regulated by both the force of gravity, which acts to slow it down, and a mysterious dark energy, which pushes matter and space apart. In fact, dark energy is thought to be pushing the cosmos apart at faster and faster speeds, causing the universe's expansion to accelerate.

The findings offer new support for the favored theory of how dark energy works—as a constant force, uniformly affecting the universe and propelling its runaway expansion. Scientists think dark energy dominates the universe, making up about 74 percent of it. Dark matter, a slightly less mysterious substance, accounts for 22 percent. So-called normal matter, anything with atoms, or the stuff that makes up living creatures, planets and stars, is only about four percent of the cosmos. ([Read more about GALEX's findings.](#))

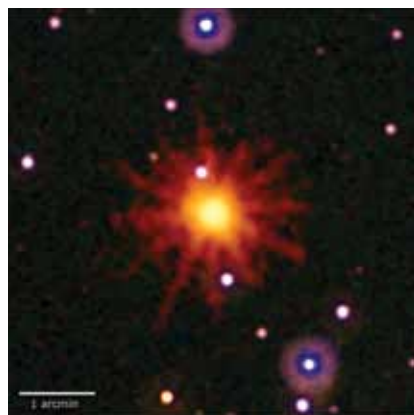
Telescopes join forces to observe unprecedented explosion

NASA's [Swift spacecraft](#), [Hubble Space Telescope](#), and [Chandra X-ray Observatory](#) teamed up to study one of the most puzzling cosmic blasts yet observed. Astronomers discovered that it was a massive explosion that may be the death of a star torn apart by a black hole.

The explosive event was located in the center of a galaxy 3.8 billion light years away and lasted for over a week, with intermittent fading and brightening episodes. Nothing as bright, long-lasting, and variable has ever been observed from extragalactic sources. Gamma-ray bursts (bursts of gamma-ray photons, the most energetic form of light) usually mark the destruction of a massive star, but flaring emission from these events never lasts more than a few hours.

Although research is ongoing, astronomers suggest that the unusual blast arose when a star wandered too close to its galaxy's central black hole. Intense tidal forces tore the star apart, and the infalling gas continues to stream toward the hole. According to this model, the spinning black hole formed an out-flowing jet along its rotational axis. A powerful blast of X- and gamma rays is seen if this jet is pointed toward Earth.

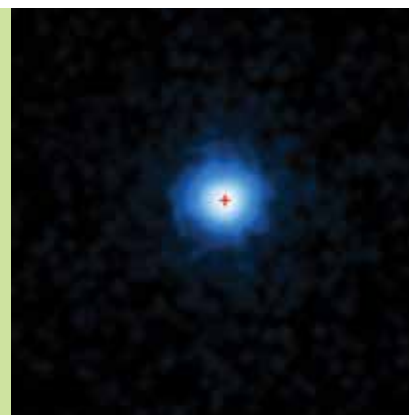
Most galaxies, including the Milky Way, contain central black holes with millions of times the Sun's mass. Black holes in the largest galaxies can be a thousand times larger. The disrupted star probably succumbed to a black hole less massive than the Milky Way's. This discovery highlights the value of being able to observe events across multiple wavelengths—optical (Hubble), X-ray (Chandra), and Gamma-ray (Swift)—to pinpoint and better observe this dramatic explosion. ([Read more about this story.](#))



(Credit: NASA/Swift/S. Immler)



(Credit: NASA/ESA/A. Fruchter, STScI)



(Credit: NASA/CXC/Warwick/A. Levan)

Images from Swift's Ultraviolet/Optical (white, purple) and X-ray telescopes (yellow, red) were combined to form the first view of the event, called GRB 110328A. The blast was detected only in X-rays, which were collected over more than three hours on March 28. The second view is a visible light image of the host galaxy (arrow) taken by Hubble on April 4. In the last image, taken by Chandra on April 4, the center of the X-ray source corresponds to the center of the host galaxy, marked with a red cross.

Fermi catches Earth thunderstorms hurling antimatter into space

In late 2010, scientists using NASA's [Fermi Gamma-ray Space Telescope](#) detected beams of antimatter produced above thunderstorms on Earth, a phenomenon never seen before.

The scientists found that these antimatter particles, called positrons, were the result of a terrestrial gamma-ray flash (TGF), a brief burst produced inside thunderstorms known to be associated with lightning. They estimate that about 500 TGFs occur around the world daily, but most go undetected. The data collected by Fermi was the first direct evidence that thunderstorms make antimatter particle beams.

Since Fermi's launch in 2008, its Gamma-ray Burst Monitor (GBM) has detected over 130 TGFs. Such events are thought to originate in the strong electric fields near the tops of thunderstorms. When the field becomes strong enough, it can drive an upward avalanche of electrons that reach speeds nearly as fast as light. These high-energy electrons emit gamma rays when deflected by air molecules. Normally, it is the resulting broad spray of gamma rays that are detected as a TGF. However, the Fermi discovery suggests that some of the gamma rays spontaneously transform into electron and positron (antimatter) pairs that are accelerated in a tight beam clear out of the atmosphere into space. When antimatter striking the Fermi spacecraft collides with a particle of normal matter, both particles are immediately annihilated and transformed into gamma rays that are detected by the GBM. Fermi had to be in the right place at just the right time to be in a beam of antimatter. This suggests all TGFs probably emit electron/positron beams.

NASA's Fermi mission was designed to observe high-energy events in the cosmos, but the discovery that thunderstorms make antimatter is an excellent example of how basic science often leads to a better understanding of processes here on Earth. ([Read more on this story.](#))

Understanding how stars, planets, and galaxies formed and evolve

Hubble Space Telescope Contributes to Nobel Prize in Physics

Observations made by NASA's [Hubble Space Telescope](#) of a special type of supernovae contributed to research on the expansion of the universe that was honored with the 2011 [Nobel Prize](#) in Physics.

Adam Riess, an astronomer at the [Space Telescope Science Institute](#) and Krieger–Eisenhower professor in [physics and astronomy at the Johns Hopkins University](#) in Baltimore, was a member of a team awarded the Nobel Prize in Physics by the Royal Swedish Academy of Sciences. The academy recognized him for leadership in the High-z Team's 1998 discovery that the expansion rate of the universe is accelerating, a phenomenon widely attributed to a mysterious, unexplained "dark energy" filling the universe. Critical parts of the work were done with NASA's Hubble Space Telescope.

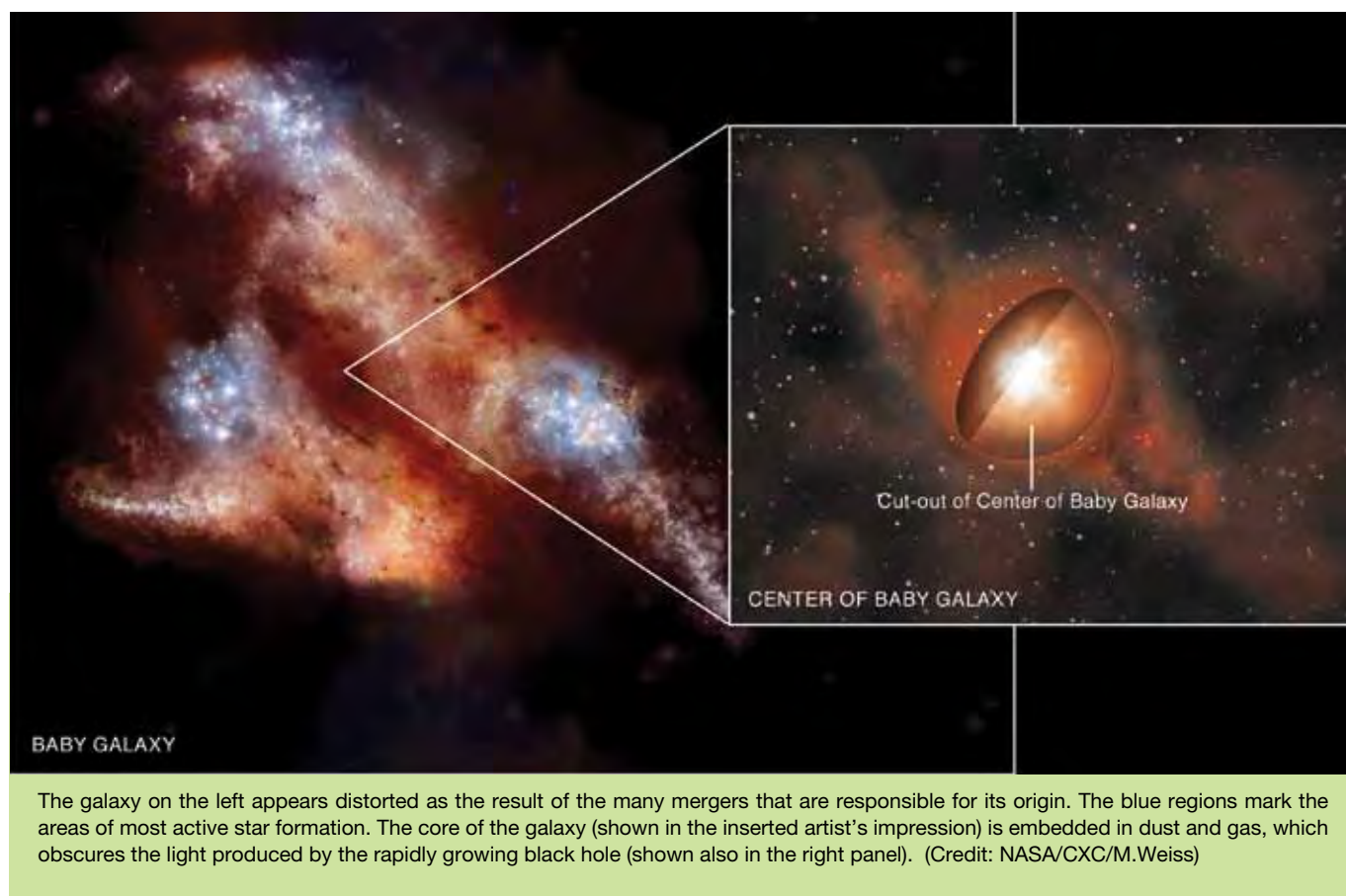
Riess shares the prize with Saul Perlmutter, an astrophysicist at the [University of California at Berkeley](#) and the [Lawrence Berkeley National Laboratory](#), whose Supernova Cosmology Project team published similar results shortly after those published by Riess and High-z teammate Brian Schmidt of the [Australian National University](#). Both teams shared the [Peter Gruber Foundation's 2007 Cosmology Prize](#)—a gold medal and \$500,000—for the discovery of dark energy, which [Science](#) magazine called "The Breakthrough Discovery of the Year" in 1998.

Riess led the study for the High-z Supernova Search Team of highly difficult and precise measurements of objects that spanned seven billion light years that resulted in the 1998 discovery that many believe has changed astrophysics forever: an accelerated expansion of the universe propelled by dark energy. Hubble measured how the brightness of some of the most distant supernovae changed over time. This established that the universe is accelerating; the unknown agent responsible for the acceleration was dubbed "dark energy." The precision of Hubble measurements of the high redshift supernovae, which had been discovered from the ground, was crucial in the demonstration that distant supernovae were fainter than expected, and that the initial deceleration of the universe has astoundingly transformed into an accelerating expansion due to the effects of dark energy. ([Read more about this story.](#))

NASA's Chandra and Hubble find massive black holes common in early universe

Astronomers using the [Hubble Space Telescope](#) and the [Chandra X-ray Observatory](#) have found the first direct evidence that massive black holes are actively growing in the centers of the most distant galaxies known: galaxies forming within 950 million years of the Big Bang.

Astronomers have long known that most galaxies in the present-day universe (including the Milky Way) harbor massive black holes at their hearts, but the origin of these black holes has long remained a mystery. They also predicted that a population of young black holes existed in the early universe, but had not observed them until now. Data obtained by



Hubble and Chandra suggest that the baby black holes found in the early universe will eventually grow to become like the giant black holes seen in the current universe.

This discovery, which combines very deep observations from Chandra and Hubble, shows that very young black holes grow in tandem with their host galaxies and are so veiled by cold gas and dust within these galaxies that only the most energetic X-rays can escape. While Hubble can see the ultraviolet and optical light from the stars in these distant galaxies, only Chandra can detect the X-ray emission from their central black holes. By pointing Chandra at a single patch of sky for more than six weeks, the astronomers obtained the deepest X-ray image ever taken. They scrutinized the data for the detection of X-rays from about 200 of the most distant galaxies identified from Hubble observations of the same patch of sky. ([Read more about these observations.](#))

WISE mission finds cool neighbors while generating an infrared legacy

Scientists using data from NASA's WISE discovered the coldest class of star-like bodies, with temperatures as cool as the human body.

Astronomers hunted these dark orbs, termed Y dwarfs, for more than a decade without success. When viewed with a visible-light telescope, they are nearly impossible to see. WISE's infrared vision allowed the telescope to finally spot the faint glow of six Y dwarfs relatively close to the Sun, within a distance of about 40 light-years.

In February 2011, WISE completed its primary mission to map the sky, looking for neighbors that scientists did not know were there—the brightest galaxies and the coolest stars. Y dwarfs are the coldest members of the brown dwarf family. Brown dwarfs are sometimes referred to as “failed” stars. They are too low in mass to fuse atoms at their cores and thus don't burn with the fires that keep stars like the Sun shining steadily for billions of years. Instead, these objects cool and fade with time, until what little light they do emit is at infrared wavelengths.

Finding and characterizing the coolest brown dwarfs will set limits on star formation processes and determine the total amount of mass in stars, a key ingredient in modeling galaxy formation, and furthering understanding of very cold, planet-like atmospheres. The atmospheres of brown dwarfs are similar to those of gas-giant planets like Jupiter, but they are easier to observe because they are alone in space, away from the blinding light of a parent star. This new Y-class

would include brown dwarfs with atmospheres cool enough to contain water vapor capable of condensing to form clouds and water. ([Read more about WISE's discovery of Y dwarfs.](#))

With the mapping of the sky recently completed in February 2011 and the first public data released on April 14, 2011 (<http://wise2.ipac.caltech.edu/docs/release/prelim/index.html>), WISE data mining has just begun ([visit the data release site](#)), but, already WISE has discovered over 100 brown dwarf stars. Along with the Y dwarfs, these include two of the lowest metallicity (metal deficient) blue compact dwarf galaxies. Very low metallicity galaxies are low redshift examples of the first generation of galaxies to form in the universe. It also has found some of the coolest brown dwarfs known.

SOFIA science observations take flight

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is nearing the end of the phase in which the SOFIA project team is developing the observatory and conducting early science flights in parallel. SOFIA is different from other missions contributing to this outcome. Instead of a spacecraft equipped with instruments, SOFIA is telescope installed in a specially modified 747 aircraft. In the next phase, SOFIA will be an operational mission. The project made significant progress in FY 2011 toward the next phase.

The project received its Reduced Vertical Separation Minimum certification, which allows SOFIA to now fly anywhere within the National Airspace System. Previously, it was restricted to a specific area for testing. The Basic Science 1 first competed science using the Faint Object Infrared Camera for SOFIA Telescope (FORCAST) started ahead of schedule on May 5. On June 23, SOFIA observed the dwarf planet Pluto as it passed in front of a distant star. This event, known as an "occultation," allowed scientific analysis of Pluto and its atmosphere by flying SOFIA at the right moment to an exact location where Pluto's shadow fell on Earth. A group of scientists and engineers from NASA's partners the German Aerospace Center, DLR, also were aboard to monitor the performance of the German-built telescope and Fast Diagnostic Camera (FDC). That camera has been used on previous flights to measure the stability of SOFIA and its optical systems. On this flight, the FDC provided supplemental observations of the Pluto occultation. ([Read more about SOFIA's observations of Pluto.](#)) In September, the aircraft received an avionics upgrade required for international flights so SOFIA could attend the annual German Aerospace Center open house in Cologne, Germany. ([Read more about SOFIA's visit.](#))

Finding planets beyond the solar system and measuring their properties

Kepler finds Earth-size planet candidates in habitable zone and a six planet system

Since its launch in March 2009, NASA's Kepler mission has been seeking evidence of Earth-size planets in orbit around Sun-like stars as part of the Agency's effort to create a census of extra-solar planets and measure their properties and discovering a fascinating variety of extrasolar planets along the way. In February 2011, astronomers using Kepler found the first Earth-size planet candidates and the first candidates in the habitable zone, a region where liquid water could exist on a planet's surface and that could potentially host life. Kepler also found six confirmed planets orbiting a sun-like star. This is the largest group of transiting planets orbiting a single star ever discovered outside the solar system. Astronomers worldwide are working to confirm these planetary candidates as actual planets, rather than false positives, using ground-based observing and sophisticated data analysis with super computers.

Five of the potential planets are near Earth-size and orbit in the habitable zone of smaller, cooler stars than the Sun. The findings increase the number of planet candidates identified by Kepler to more than 1,235 in orbiting around 1,000 stars. Of these planets, 68 are approximately Earth-size, 288 are super-Earth-size, 662 are Neptune-size, 165 are the size of Jupiter, 19 are up to twice the size of Jupiter, 15 are more than twice the size of Jupiter, and 18 candidates show only one transit. ([Read more on these discoveries.](#))

Outcome 2.4					
Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.					
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.4.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7UNIV1 Green	8AS01 Green	9AS1 Green	10AS01 Green	AS-11-1 Green

FY 2011 Performance Goal					FY 2011
By 2015, launch at least one mission in support of this outcome.					2.4.1.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Complete the Nuclear Spectroscopic Telescope Array (NuSTAR) Systems Integration Review.	None	None	None	10AS02 Green	AS-11-2 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.4.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in understanding the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7UNIV6 Green	8AS06 Green	9AS6 Green	10AS09 Green	AS-11-3 Green
FY 2011 Performance Goal					FY 2011
Design and assemble James Webb Space Telescope (JWST).					2.4.2.2 Yellow
Why NASA rated Performance Goal 2.4.2.2 Yellow: The measure was placed in the FY 2012 Congressional Justification prior to the project's replan. Based on this, the baseline assumption for the measure was that the project was still operating under the original baseline. The new estimated baseline, which was approved late in the fiscal year, resulted in a 78% increase in the estimated lifecycle cost from the original baseline. The new estimated baseline has been endorsed by the NASA Administrator, all reporting required by Section 103 of the NASA Authorization Act of 2005 has been completed, and 95 percent of the FY 2011 planned activities were accomplished, indicating that it is likely to stay on track for the new estimated cost. Specifically, JWST achieved 19 of its 21 planned FY 2011 milestones on or ahead of schedule, one milestone was achieved one month late and one milestone was delayed due to design changes, and is on track to achieve its FY 2012 milestones. The one planned FY 2011 milestone that was achieved a month late and the one that has been delayed do not impact the critical path. (See page 130 for the Performance Improvement Plan.)					
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete new James Webb Space Telescope (JWST) mission re-baseline.	7UNIV4 Green	8AS04 Green	9AS4 Green	10AS06 Green	JWST-11-1 Green
FY 2011 Performance Goal					FY 2011
Develop and operate an airborne infrared astrophysics observatory.					2.4.2.3 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Initiate the Stratospheric Observatory for Infrared Astronomy (SOFIA) science observations.	None	None	9AS5 Yellow	10AS07 Yellow	AS-11-4 Green
FY 2011 Performance Goal					FY 2011
Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.					2.4.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Demonstrate planned progress in generating a census of extra-solar planets and measuring their properties. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	7UNIV7 Green	8AS07 Green	9AS7 Green	10AS10 Green	AS-11-5 Green
Uniform and Efficiency Measures					
	FY07	FY08	FY09	FY10	FY 2011
Complete all development projects within 110 percent of the cost and schedule baseline.	7UNIV9 Red	8AS09 Yellow	9AS12 Yellow	10AS11 Green	AS-11-6 White
Why NASA rated APG AS-11-6 White: The metric indicates the final development costs, once a mission launches, but there were no planned launches for FY11 in Astrophysics. Hence the measure is not applicable to this fiscal year, and rated white.					
Deliver at least 90 percent of scheduled operating hours for all operations and research facilities.	7UNIV10 Green	8AS10 Green	9AS13 Green	10AS12 Green	AS-11-7 Green
Peer-review and competitively award at least 95 percent, by budget, of research projects.	7UNIV11 Green	8AS11 Green	9AS14 Green	10AS13 Green	AS-11-8 Green
Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.	7UNIV12 Green	8AS12 Yellow	9AS15 Green	10AS14 Green	AS-11-9 Green

Create the innovative new space technologies for our exploration, science, and economic future.

Creating the innovative new space technologies for America's exploration, science, and economic future requires development of capabilities that do not yet exist or are currently too immature and too high-risk to use for current missions. The inclusion of an untried technology poses risks to planned budgets and schedules due to the unknown and unpredictable issues that may arise. To responsibly accelerate technologies for enabling future missions, NASA, through the Office of the Chief Technologist and the Exploration Research and Development programs, has created a portfolio that spans the technology readiness level (TRL) spectrum and balances mission-focused and transformational technology investments. NASA prioritizes this portfolio using the Space Technology Grand Challenges, a set of important space-related problems that must be solved to efficiently and economically achieve NASA's missions, and the Space Technology Roadmap, an integrated set of 14 technology area roadmaps. This strategic goal addresses three categories of technology investments that will expand the NASA portfolio across the TRL spectrum.

The first set of technology investments focuses on fostering early-stage innovation in which a multitude of concept technologies are developed through a process of idea generation, research, innovation, and experimentation. NASA learns valuable lessons from these early-stage activities, even when some of the technologies do not work as intended. NASA's technology efforts through student grants, fellowships, and other opportunities to inspire innovators will help expand a future workforce and stimulate greater creativity in the Nation.

The second category focuses on taking the best low-TRL technologies—those studied under the first category—and determining which of these “disruptive” innovations and technologies are viable through further technology development, prototyping, experimentation, testing, and demonstrations. The goal of these technology activities is to validate whether or not substantial improvements in affordability, capability, or reliability are truly achievable for missions.

The third type of technology investment supports technology development targeting near-term unique spacecraft or mission needs. Through focused studies, dialogue, and development activities across NASA, as well as with academia and industry, these technology activities will provide improved future technologies that are closely aligned with known requirements. Building a comprehensive portfolio with both near- and long-term development activities will allow NASA to discover and advance high-payoff technologies that may fundamentally change the way humankind lives and explores.

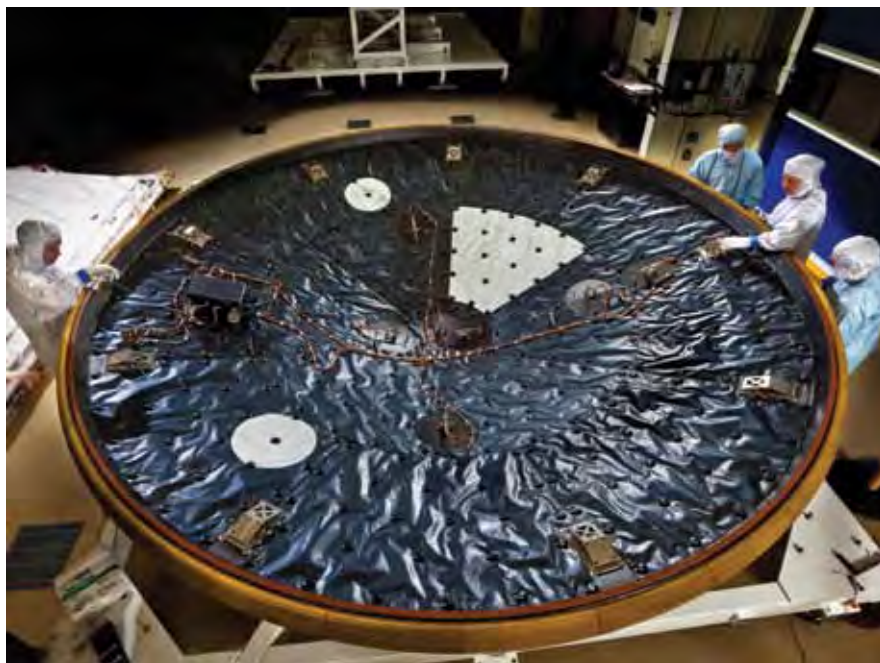
Benefits

The Nation's economic competitiveness is due in large part to decades of investment in technology and innovation. Since NASA's inception, it has used innovative technology development programs to generate new science, exploration, and aeronautics capabilities. The Agency's innovations have enabled missions, contributed to other government agencies' needs, cultivated commercial aerospace enterprises, and fostered a technology-based U.S. economy. NASA will continue this tradition. Aggressive technology investments for exploration and discovery missions will create a vibrant commercial space sector through the establishment of new markets in future technologies. The Agency will transfer developed technologies, processes, discoveries, and knowledge to the commercial sector through various means including licenses, partnerships, and cooperative activities. These transferred technologies will be used to create products, services, cascading innovations, and other discoveries to fuel the Nation's economic engine and improve quality of life.

Risk to Achieving Strategic Goal 3

Implementation of a New Approach. Over the last decade, NASA's technology development efforts have focused on incremental advances that enabled specific capabilities or missions. However, the increasing complexity and variety of challenges presented by current science, exploration, and aeronautics missions renders the incremental technology development model insufficient to meet mission needs. To enable NASA's long-term mission success requires accepting an aggressive technology development approach that has the potential to leap beyond the incremental successes and create new technologies that can dramatically improve Agency capabilities. With a willingness to dedicate funds to pure technology development, NASA is accepting a higher level of technology development risk related to unknown and unpredictable issues that may arise during the aggressive technology development process.

NASA is addressing this risk by developing a diverse portfolio spanning the TRL spectrum, including near-term, mission-focused technologies and longer-term, high-payoff transformational technologies that solve difficult space-related problems and together ensure mission success. Through implementation of such a sustainable, strategic approach toward technology development, NASA will address the immediate needs of its missions, foster an innovative culture within the Agency to meet long-term strategic goals, and contribute to the Nation's technological competitiveness.



The Mars Entry, Descent and Landing Instrument (MEDLI) is visible at the middle left of the aeroshell/heatshield for the Mars Science Laboratory (MSL). Built by the Langley Research Center, MEDLI is actually made up of two kinds of instruments (with seven sensors of each kind) that are installed in 14 places on the spacecraft's heat shield. The MEDLI instrumentation will measure heat shield temperatures and atmospheric pressures during the spacecraft's high-speed, extremely hot entry into the Martian atmosphere. The data will help engineers design future systems for Mars entry that are safer, more reliable, and lighter weight. (Credit: Lockheed Martin)

Outcome 3.1

Sponsor early stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.

The Office of the Chief Technologist (OCT) considers early-stage innovation—low technology readiness level (TRL) technology—to be the foundation of the development process. Investment in low-TRL technology increases knowledge and capabilities in response to new questions and requirements, and it stimulates creative new solutions to the challenges faced by NASA and the larger aerospace community.

Investments in low-TRL projects, through partnerships with the public and private sectors, have historically benefited the Nation on a broad basis, generating new industries and spin-off applications and providing a cadre of new technology-savvy innovators to fuel the Nation's high-tech economy.

Below are some of activities pursued and achievements made during FY 2011 for this outcome.

Exploring revolutionary concepts

Renewed NIAC exceeds target, spurs imaginative technologies

In 2011, NASA Innovative Advanced Concepts, or NIAC, selected 30 proposals for funding, exceeding its target of 10 proposals by 300 percent. OCT chose the advanced concepts for study based on their potential to transform NASA's future space missions, enable new capabilities, or significantly alter current approaches to launching, building, and operating space systems.

The original NIAC program ran from 1998 to 2007. With NASA's renewed emphasis on space technology development, NASA re-established NIAC in 2011 to fund early studies of visionary concepts with long term, challenging development goals. The new NIAC office allows proposal opportunities to be open to principal investigators or teams both internal and external to NASA.

These first NIAC proposals included a broad range of imaginative and creative ideas, such as changing the course of dangerous orbital debris, developing a spacesuit that uses flywheels to stabilize and assist astronauts as they work in microgravity, using three dimensional printing to create a planetary outpost, and developing multiple innovative propulsion and power concepts needed for future space mission operations. Each award received approximately \$100,000 for one year to advance the innovative space technology concept and to help NASA meet future mission requirements. For a complete list of the selected proposals, and more information about the program, visit http://www.nasa.gov/offices/oct/early_stage_innovation/niac/2011_phase1_selections.html.

Tapping non-traditional sources through Centennial Challenges

The Centennial Challenge Program provides cash prize incentives to non-traditional sources for innovations of interest and value to NASA and the Nation by conducting prize purse competitions to achieve challenging technology performance targets. NASA provides the prize purse while non-profit entities manage the competitions at no cost to NASA. These competitions expand the pool of innovators and stimulate effort from non-traditional sources to find solutions to technical challenges that support NASA's missions in aeronautics and space.

NASA and its partners have been conducting Centennial Challenges for a variety of technologies and capabilities since 2006. In 2011, there were two Centennial Challenge competitions, summarized below.

NASA awards historic Green Aviation prize

NASA has awarded the largest prize in aviation history—a Centennial Challenge created to inspire the development of more fuel-efficient aircraft and spark the start of a new electric airplane industry. The technologies demonstrated by the Comparative Aircraft Flight Efficiency (CAFÉ) Foundation Green Flight Challenge, sponsored by Google, may end up in general aviation aircraft, spawning new jobs and new industries for the 21st century.

The Green Flight Centennial Challenge succeeded in advancing technologies in aircraft fuel efficiency and reduced emissions with cleaner renewable fuels and electric aircraft. Fourteen teams originally registered for the competition. Three teams successfully met all requirements and competed in September 2011 in the skies over the Charles M. Schulz Sonoma County Airport in Santa Rosa, California. Following remarks by NASA Acting Chief Technologist Joseph Parish and CAFÉ Foundation President Brien Seeley, NASA awarded the first place prize of \$1.35 million to Pipistrel-USA.com of State College, Pennsylvania, and second place prize of \$120,000 to eGenius of Ramona, California.

The winning aircraft had to fly 200 miles in less than two hours and use less than one gallon of fuel per occupant, or the equivalent in electricity. The first and second place teams, which were both electric-powered, achieved about twice the fuel efficiency requirement of the competition, meaning they each flew 200 miles using a little over a half-gallon of fuel equivalent per passenger.

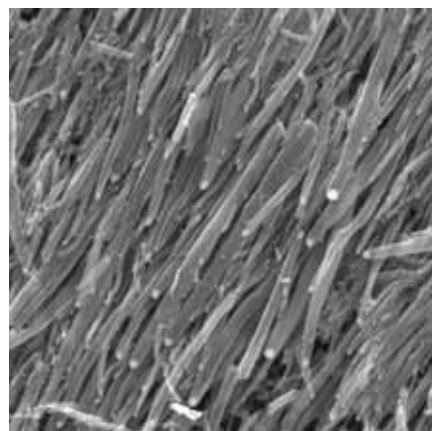


The Pipistrel-USA Taurus G4 aircraft prepares to takeoff for the miles per gallon flight during the 2011 Green Flight Challenge on September 27, 2011. (Credit: NASA/B. Ingalls)

Strong Tether prize remains elusive

NASA conducted the Strong Tether Challenge on August 12 as part of the 2011 Space Elevator Conference. The Space Elevator Conference, sponsored by Microsoft, the Leeward Space Foundation, and the International Space Elevator Consortium has hosted the tether competition for five years and for this, the fifth year in a row, there was not a winner. Although no competitor has been able to claim the Centennial Challenge prize, over the years, the competitors have developed increasingly stronger tethers as they discovered new and innovative methods for fabricating tethers with carbon nanotube technology.

The Strong Tether Challenge focuses material science technologies to create long, very strong cables (known as tethers) with exceptionally high strength-to-weight ratio. Such tethers will enable advances in aerospace capabilities, including reduction in rocket mass, habitable space structures, tether-based propulsion systems, solar sails, and even space elevators. Dramatically stronger and lighter materials are also revolutionizing the engineering of down-to-earth structures like aircraft bodies, sporting good equipment, and even structures of bridges and buildings. This year, two competitors unsuccessfully tried for the Tether challenge's \$2 million prize purse.



Carbon nanotubes, shown here, are long, hollow tubes formed from one-atom thick sheets of carbon. Individual nanotubes naturally align themselves into ropes. (Credit: NASA)

Maintaining a culture of innovation

NASA awards Center Innovation Funds

In 2011, NASA distributed funds among its 10 Centers to support more than 82 low-TRL, innovative technology initiatives that leverage Center talent and capability.

The objective of the Center Innovation Fund is to stimulate and encourage creativity and innovation within the NASA Centers by funding activities that fall within the scope of NASA Space Technology or address a significant national need. Through the Center chief technologist, each Center conducted a competition to select projects. NASA scientists and engineers lead the projects, which are scored annually by OCT to guide follow-on funding distribution.

Working with Small Business

The Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs as implemented by NASA provide an opportunity for small, high technology companies and research institutions to participate in NASA's research and development efforts in key technology areas. These programs have produced innovative technologies for NASA missions, in accordance with NASA's Strategic Plan, as well as commercial products for the betterment of humankind since the effort's beginning in 1984.

Awards help small business partners develop technologies

OCT exceeded its 2011 goal of infusing 24 percent of SBIR/STTR technology programs funded from fiscal years 2004 through 2008 into NASA projects by achieving 28 percent. During that time period, NASA initiated 766 projects, of which 218 developed technologies that were:

- Infused into NASA programs;
- Adopted for use in future missions;
- Chosen for further development after emerging from SBIR/STTR Phase I and Phase II; or
- Were otherwise meaningfully participating in NASA's projects and activities.

The purpose of Phase I is to determine the scientific, technical, and commercial merit and the feasibility of the proposed innovation (only Phase I contractors are eligible for Phase II funding agreements). Successful completion of Phase I objectives is a prerequisite for consideration of a Phase II award. The purpose of Phase II is the development, demonstration, and delivery of the innovation.

During 2011, NASA selected 451 proposals from small business firms for Phase I awards and 213 proposals for Phase II awards. In addition, NASA selected 45 STTRs for Phase I awards and 27 for Phase II awards. NASA is executing Phase IIE options with 24 firms that have validated non-SBIR matching funds. Phase IIE options are intended to encourage the transition of Phase II contracts into Phase II opportunities by providing a cost share extension of Phase II contracts. Under this option, NASA will match non-SBIR/non-STTR investment from a NASA project, NASA contract, or third commercial investor. Maximum value and period of performance for Phase I and Phase II contracts and more information may be found at <http://sbir.gsfc.nasa.gov/SBIR/SBIR.html>.

During FY 2011, award amounts have been increased: Phase I awards from \$100,000 to \$125,000, Phase II awards from \$600,000 to \$750,000, and the Phase IIE option from \$150,000 to \$250,000 with non-SBIR/STTR matching funds. This increase is within the March 2010 Small Business Administration authorization of a new threshold for SBIR awards. The authorization also introduced subtopics with a Technology Available (TAV) designation, which addresses the objective of using NASA intellectual property as a basis for the proposed innovation. Based on NASA's Office of Inspector General recommendations, NASA has increased internal controls to help prevent waste, fraud, and abuse in the program. Additionally, NASA leveraged the Recovery Act investment, with its unprecedented accountability and transparency, to pilot these controls before moving them mainstream, in this year. These changes included additional training for contracting officer's technical representatives (the civil servants who serve as liaisons between the government and the contractors and are responsible for authorizing contract expenditures) and proposal reviewers, virtual site visits for first time Phase II awardees, and increased documentation in contract files.

Accelerating Space Technology research

Inaugural class of NASA Space Technology Research Fellows Selected

Space Technology Research Opportunities (ESI-STRO), which competitively select high risk, high payoff groundbreaking research in advanced space technology. As part of NASA's strategy to develop the technological foundation for



SBIR contracts with Langley Research Center and satellite data from the Stennis Space Center allowed Colorado-based Terra Metrics, Inc., to develop a satellite imagery and terrain data product line that features in Google Earth, as well as a three-dimensional, terrain-rendering engine that enables synthetic vision solutions for aircraft, enhancing pilot's situational awareness during flight. (Credit: Terra Metrics)

its future science and exploration missions, the Agency seeks graduate students who will be dedicated to performing innovative space technology research while building the skills necessary to become future technological leaders.

FY 2011 featured the selection and award of the inaugural class of NASA Space Technology Research Fellows. The Space Technology Research Grants Program awarded 80 graduate students fellowships to pursue master's or doctoral degrees in relevant space technology disciplines at their respective institutions. Fellows will perform innovative space technology research while building the skills necessary to become future technological leaders.

These and future fellows will provide the Nation with a pipeline of highly skilled engineers and technologists to improve U.S. competitiveness. The fellows will perform graduate student research on their respective campuses and at NASA Centers and nonprofit U.S. research and development laboratories. For a list of fellowship recipients, their research institutions and their research topics, please visit http://www.nasa.gov/offices/oct/early_stage_innovation/grants/2011_inaugural_class.html.

Outcome 3.1					
Sponsor early-stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.					
FY 2011 Performance Goal					FY 2011
Explore revolutionary aerospace concepts, with an initial research phase for preliminary assessment of a broad range of ideas, and a second phase for further development of the most promising concepts.					3.1.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Initiate 10 Phase I research efforts to explore revolutionary aerospace ideas.	None	None	None	None	ST-11-1 Green
FY 2011 Performance Goal					FY 2011
Provide cash prize incentives to non-traditional sources for innovations of interest and value to NASA and the Nation.					3.1.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Conduct at least two Centennial Challenge competitions.	7ESRT3 Green	8IPP06 Green	None	None	ST-11-2 Green
FY 2011 Performance Goal					FY 2011
Establish and maintain a culture of innovation at each of the 10 NASA Centers through the development of new Center ideas and technologies.					3.1.1.3 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Twenty innovative projects will be initiated across the NASA Centers.	None	None	None	None	ST-11-3 Green
FY 2011 Performance Goal					FY 2011
Increase the proportion of Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) technologies successfully infused into NASA programs/projects.					3.1.1.4 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
At least 24 percent of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase II technology projects awarded between 2004-2008 will be infused into NASA programs and projects.	None	None	None	10IPP07 Green	ST-11-4 Green
FY 2011 Performance Goal					FY 2011
Increase the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase III contracts initiated or expanded.					3.1.1.5 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
At least 40 of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) technologies will be advanced to Phase III (received non-SBIR/STTR funding).	None	None	None	10IPP04 Green	ST-11-5 Green
FY 2011 Performance Goal					FY 2011
Accelerate the development of push technologies to support the future space, science and exploration needs of NASA, other government agencies, and the commercial space sector.					3.1.1.6 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Select 100 NASA space technology research activities.	None	None	None	None	ST-11-6 Green

Outcome 3.2

Infuse game changing and crosscutting technologies throughout the Nation's space enterprise, to transform the Nation's space mission capabilities.

For a sustainable set of affordable programs that achieve longer-term goals, NASA requires a faster, more aggressive strategy for creating and applying new technologies. Without a robust effort that matures technologies and establishes their feasibility, the ideas and transformational concepts developed at a low technology readiness level (TRL) may not materialize into benefits for future NASA missions or the Nation's economy. The Office of the Chief Technologist (OCT) bridges the gap between idea formulation and mission infusion to deliver improvements to future missions. OCT focuses on maturing mid-TRL technologies and proving the feasibility of advanced space concepts and technologies that may lead to entirely new approaches to space system design and operations, exploration, and scientific research. Through significant modeling, analysis, ground-based testing, and laboratory experimentation, OCT will mature technologies in preparation for potential system-level flight demonstrations within NASA itself or by other government agencies. Executing these challenging laboratory and space flight demonstrations requires creating technology projects with well-defined milestones and schedules, developing facilities, laboratories, and flight test opportunities, fabricating materials, hardware, and software, developing and integrating technologies, and conducting demonstrations.

Building Game-Changing Technology

NASA's Game Changing Technology (GCT) investments focus on maturing advanced space technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs.

In 2011, GCT released a Broad Agency Announcement for Unique and Innovative Technologies to enable revolutionary improvements to the efficiency and effectiveness of the Nation's space capability and made selections for three awards. The GCT theme funded technology development work for a ground composite cryotank structural demonstration, a hypersonic inflatable aerocapture demonstration, and a low-density supersonic decelerator. Through significant ground-based testing and/or laboratory experimentation, GCT matures technologies in preparation for potential system level flight demonstration within OCT Crosscutting Capability Demonstrations, within other NASA mission directorates, or by other government agencies. GCT also developed 10 pre-competitive concept packages in areas including tether propulsion, avionics, power beaming, and horizontal launch.

NASA selects program's first demonstration missions

Technology Demonstration Missions (TDM) demonstrate and infuse crosscutting, game changing space technologies. OCT released TDM's inaugural Broad Agency Announcement on March 1, and received 47 space technology demonstration proposals by June 24. On August 22, OCT selected three demonstration missions: a deep space atomic clock for space navigation and timing, a mission-capable solar sailing system that would not require a propellant, and a demonstration of next-generation optical communications. OCT selected these crosscutting flight demonstrations because of their potential to provide tangible, near-term products and infuse high-impact capabilities into NASA's future space missions.

The three funded space technology demonstration missions kicked off in September 2011. The projects incorporate all elements of the flight test demonstration, including test planning, development of flight hardware, launch, ground operations, and post-testing assessment and reporting. The atomic clock and solar sail will be ready for flight in three years. The optical communications team anticipates it will take four years to mature their technology for flight. Each of the selected teams also will receive funding from partners who plan on using the technologies as part of future space missions. The Space Technology Program is cost



A four quadrant, 65-foot (20-meter) solar sail system is fully deployed for testing in 2005. The design was another solar sail tested by L'Garde, Inc., the company that will be conducting the solar sail demonstration mission for TDM. (Credit: NASA)

Outcome 3.2					
Infuse game changing and crosscutting technologies throughout the Nation's space enterprise to transform the Nation's space mission capabilities.					
FY 2011 Performance Goal					FY 2011
Transition developed game changing technologies to the technology demonstration programs or directly to Mission Directorates for mission insertion.					3.2.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Initiate ten conceptual studies to define potential game changing development projects.	None	None	None	None	ST-11-7 Green
FY 2011 Performance Goal					FY 2011
Mature technologies that enable small satellites to provide game changing capabilities for the government and commercial space sectors.					3.2.2.1 Green
FY 2011 Performance Goal					FY 2011
Demonstrate small satellite capabilities with game changing and crosscutting potential for the government and commercial space sectors.					3.2.3.1 Green
FY 2011 Performance Goal					FY 2011
Infuse game changing and crosscutting technologies into future NASA missions through flight or relevant environment demonstrations.					3.2.4.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Select two candidate system level technologies that will provide new capabilities for future missions.	None	None	None	None	ST-11-10 Green
FY 2011 Performance Goal					FY 2011
Perform sub-orbital, simulated zero-gravity and other space analog flight opportunities to develop and demonstrate emerging ideas and technologies.					3.2.5.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Select and fly technology payloads from NASA, other government agencies, industry, and academia using flight services procured from at least three commercial reusable suborbital and parabolic platform providers.	None	None	None	None	ST-11-11 Green

Outcome 3.3

Develop and demonstrate the critical technologies that will make NASA's exploration, science, and discovery missions more affordable and more capable.

The purpose of mission-driven technology development is to meet unique near-term mission needs within technical, cost, and schedule goals. NASA is prioritizing the desired set of future technologies that will offer the most synergies and advancement of mission capabilities. The Agency is enabling advances and improved performance by furthering existing evolutionary technologies, as well as developing revolutionary new technologies. It also is balancing potential technology benefits with specific mission risks to establish the appropriate time frame to infuse each emerging technology.

NASA develops mission driven technologies to meet unique near-term mission needs

NASA's Exploration Technology Development Program (ETDP) developed and demonstrated a number of technologies designed to enable science and exploration missions in FY 2011.

Early in the fiscal year, the Radiation Assessment Detector (RAD) was delivered and integrated onto the NASA Science Mission Directorate's Mars Science Laboratory rover, *Curiosity*. RAD will aid future human missions to Mars by providing information about the radiation environment on Mars and on the way to Mars.



RAD, shown prior to its installation, will monitor high-energy atomic and subatomic particles from the Sun, distant supernovae, and other natural sources. These particles are natural radiation that could be harmful to astronauts on a Mars mission. This image shows the flight hardware with a red "remove before flight" cover on top of the instrument's telescope. (Credit: NASA/JPL-Caltech/SwRI)

In February, ETDP launched the human-like Robonaut 2 hardware to the International Space Station (ISS) on STS-133. The 330-pound Robonaut 2 consists of a head and a torso with two arms and two dexterous hands. Engineers are monitoring how it operates in near microgravity, with the objective of using it as a robotic assistant that can work alongside the crew. Currently Robonaut is confined to operations in the ISS' Destiny laboratory. However, future enhancements and modifications may allow it to move more freely around the interior or outside the complex.

Studying future technologies

In support of future technology activities, NASA issued Broad Agency Announcements for Cryogenic Propellant Storage and Transfer and Solar Electric Propulsion mission concept studies in May and June. NASA selected four companies in early August to perform Cryogenic Propellant Storage and Transfer mission concept studies. The concept studies will test and validate key capabilities and technologies required for future exploration elements such as large cryogenic propulsion stages and propellant depots. Solar Electric Propulsion mission concept studies will be selected in FY 2012.

Outcome 3.3					
Develop and demonstrate the critical technologies that will make NASA's exploration, science, and discovery missions more affordable and more capable.					
FY 2011 Performance Goal					FY 2011
Demonstrate robotic technologies that support in-space operations, scientific discovery, and work as assistants with the crew.					3.3.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Launch Robonaut 2 to the ISS and demonstrate teleoperation from the ground.	None	None	None	None	ERD-11-7 Green
FY 2011 Performance Goal					FY 2011
Develop advanced spacesuits to improve the ability of astronauts to conduct Extra-Vehicular Activity (EVA) operations in space including assembly and service of in-space systems and exploration of surfaces of the Moon, Mars, near-Earth objects (NEOs), and other small bodies.					3.3.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Test breadboard Extra-Vehicular Activity (EVA) Portable Life Support System (PLSS) technologies to enable advanced spacesuits for human deep space exploration.	None	None	9AC14 Green	None	ERD-11-8 Green
			9AC6 Green		
		8CS06 Yellow	9CS5 Red		
FY 2011 Performance Goal					FY 2011
Develop technologies and mission concepts for demonstrating in-space cryogenic propellant storage and transfer making exploration and science missions more affordable and capable.					3.3.2.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop and test Liquid Acquisition Devices (LADs) and mass-gauging to support future Cryogenic Propellant Storage And Transfer (CRYOSTAT) missions.	None	None	None	None	ST-11-12 Green

Outcome 3.4

Facilitate the transfer of NASA technology and engage in partnerships with other government Agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.

While technology and innovation are critical to accomplishing NASA's missions, it also benefits the U.S. economy through transfer of new technologies for other applications. NASA makes a determined effort to transfer technologies outside of the Agency and to develop technology partnerships. NASA's technology investments support advancement in key research areas, fuel rapid improvements in mission capabilities, foster a robust industrial base, improve the Nation's competitive position in the international marketplace, enable new industries, improve quality of life, and contribute to economic growth.

NASA seeks partnerships and cooperative activities with the emerging commercial space sector. Three key themes underscore this effort: considering the private sector as an investment partner and sharing the cost of developing a capability; purchasing services rather than hardware when possible; and fostering the creation of broader opportunities for innovation. Pursuing these partnership themes brings direct value to NASA's current and future missions, advances the interests of the partners, and encourages additional commercial space development. In addition to partnership strategies, NASA seeks to transfer its technologies directly to other government agencies, the national aerospace industry, and the broader U.S. commercial sector. NASA-spurred advances in energy, communication, health, materials science, and other fields generate spinoff applications that benefit the Nation. The Agency has established a core team at each Center charged with technology transfer, licensing, and new partnership development, and these teams work closely with scientists and engineers to match NASA technologies with the needs of external organizations.

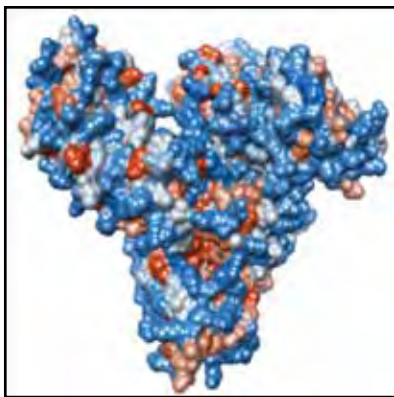
Guided by the Office of Chief Technologist (OCT), the Innovative Partnerships Office has a dual role: to seek partnerships that can leverage technologies, expertise, and capabilities to advance NASA's missions and to provide access to NASA resources including intellectual property that will benefit the United States through economic growth and improved quality of life. To achieve these two complementary objectives, NASA technology transfer professionals work closely with NASA Center scientists, engineers, and software developers to foster commercial application of NASA's wide spectrum of research and technology development. As noted in the annual NASA *Spinoff* publications (<http://www.sti.nasa.gov/tto/>), partnerships forged between NASA and others with shared vision and objectives have saved hundreds of lives, created thousands of jobs, provided millions of dollars in cost avoidance, and generated millions of dollars in revenue. More about the Agency's technology transfer activities also is available on NASA's Open Government Initiative site at <http://www.nasa.gov/open/plan/technology-transfer.html>.

In FY 2011, NASA executed over 292 Space Act Agreements, signed 562 Software Use Agreements, filed 101 Patent applications, signed 31 invention licenses, and made 1,335 invention disclosures. These measures are tracked in the NASA Technology Transfer System (NTTS).

Documenting successful technology transfers

NASA missions have given the world extraordinary new knowledge about our planet and the universe. Sometimes, they have even challenged what we think we know. Along the way, the technologies and capabilities NASA has developed to enable those missions have transformed life on Earth.

Since 1976, NASA has provided evidence of its technology transfer successes using its annual *Spinoff* publication to document examples of private sector companies developing products and services derived in part or in full from NASA technologies and other resources. In *Spinoff*, NASA highlights some of the most recent of these societal benefits generated by aeronautics and space missions. The outcomes of these partnerships have reached throughout the economy and around the globe, as the resulting commercial products contributed to the development of services and technologies in the fields of health and medicine, transportation, public safety, consumer goods, environmental resources, computer technology, and industry.



NASA experiments with protein crystal growth in space led to the first-ever synthetic albumin for drug delivery and a unique line of skin-care products. (Credit: New Century Pharmaceuticals)

This year's issue of *Spinoff* featured 43 stories of successful NASA technology transfer (including 21 articles about Small Business Innovative Research (SBIR)-developed technologies). This year's publication spans a remarkable field of innovations, including the following stories:

Bioreactors drive advances in tissue engineering

Johnson Space Center innovators created a rotating wall bioreactor that mimics microgravity conditions, allowing for healthier, more natural-forming cell cultures. Licensed to Synthecon, Inc., of Houston, the technology now enables drug development and medical research into treatment for conditions such as diabetes and cancer.

Protein innovations advance drug treatments, skin care

While at Marshall Space Flight Center, Dan Carter and colleagues mapped the atomic structure of albumin, an important blood protein, for the first time. Carter formed New Century Pharmaceuticals of Huntsville, Alabama, to build on this achievement, resulting in new skin care products and platforms for cancer treatment.

High-pressure systems suppress fires in seconds

By applying principles from a new kind of rocket engine—developed by Orbital Technologies Corporation of Madison, Wisconsin, under SBIR contracts with Marshall Space Flight Center—to fire hose nozzles, company subsidiary HMA Fire improved the performance of its ultra- high pressure fire suppression systems, which extinguish many fires in significantly less time and using less water than traditional systems.

Retrofits convert gas vehicles into hybrids

Working with Glenn Research Center through the NASA Illinois Commercialization Center, NetGain Technologies LLC of Lockport, Illinois, developed a retrofit system for converting gas-powered vehicles to gas-electric hybrids. The partnership also resulted in a line of electric motors for vehicles marketed by NetGain Motors, Inc., the production of which supports over 100 jobs at the company's manufacturing facility.

Coating processes boost performance of solar cells

While working on Glenn Research Center-funded projects, scientist Maria Faur invented a process for coating solar cells that both significantly reduces production costs and increases cell efficiency. Faur's company, North Olmstead, Ohio-based SPECMAT, Inc., has licensed the process to a company that believes it could revolutionize the solar energy industry.

Controller chips preserve microprocessor function

To develop controller technology for a variety of missions, Marshall Space Flight Center partnered with a San Diego-based company, Space Micro, Inc., through the SBIR program. Today, the technology is embedded in the company's entire series of high-performance, radiation-hardened computers for space. The company has expanded from four employees at the beginning of its NASA partnership to 43 today, growing from a \$1 million to a \$8 million company.

These benefits and myriad additional benefits are visible in our everyday lives in a wide array of applications, and the serve as a testament to NASA's ingenuity and success in transferring space technologies back down to Earth.



Work in higher-powered, lower-cost, versatile, and even reusable vortex hybrid rocket engines that effectively manage ultra-high pressure flows resulted in a new low volume, high-pressure fire suppression system. In one test, this system extinguished a standard fire in 80 percent less time and with six percent less water than standard methods. (Credit: Orbital Technologies Corporation)

Managing NASA's technology portfolio

National Academies evaluating NASA's space technology roadmaps

In FY 2011, NASA developed a set of 14 space technology roadmaps and engaged the National Academies to review the roadmaps and evaluate the balance of near-term mission-focused technology and longer-term transformational technology.

The Aeronautics and Space Engineering Board (ASEB) released an interim report on their review of NASA's draft Space Technology Roadmaps. In early 2012, the steering committee will conclude with a final report, which will provide specific guidance on how technology development funded by the Space Technology program can enhance the Agency's space science and exploration capabilities. For more information on the evaluation, visit ASEB's site at http://sites.nationalacademies.org/DEPS/ASEB/DEPS_059552.

Tracking NASA's technologies

NASA must capture the investments in space technology and make them available for strategic coordination internally and accessible to industry, academia, and international partners to further cultivate technological innovation and entrepreneurship in the commercial space sector. Consistent with this objective, NASA is developing a Technology Portfolio Tracking System with the capability to document, coordinate, and prioritize Agency-level technology strategic investments to ensure a balanced portfolio of both near-term NASA mission technologies and longer-term transformational technologies that benefit both Agency programs and national needs. The system will enable NASA to further prioritize the NASA Technology Portfolio investments against the Space Technology Roadmaps and the Space Technology Grand Challenges, as well as mission directorate needs.

The NASA Technology Portfolio Tracking System will provide an integrated, dynamic, Web-accessible interface allowing both internal and public engagement, and tracking of NASA technology investments through their life cycles, from proposal through project and product development. Its concept and development leverages the best practices, features and baseline knowledge of previously developed database systems. The system will store value-added information about NASA's technology investments, track technologies through various stages of maturity and facilitate mapping technologies to projects for management and accountability. This fiscal year, NASA planned to award a contract to develop the database system in time to see it completed by the end of the year, but due to delays in funding that resulted from the continuing resolutions, the award was not made until late summer. NASA expects to complete this work in FY 2012, and by the end of the fiscal year, the system should hold about 75 percent of the NASA technology portfolio programs' data.

Outcome 3.4						
Facilitate the transfer of NASA technology and engage in partnerships with other government agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.						
FY 2011 Performance Goal					FY 2011	
Establish 12 technology-related significant partnerships that create value for programs and projects. Track both quantitative dollar value and qualitative benefits to NASA (e.g., reduced volume or mass, improved safety) per year.					3.4.1.1 Green	
FY 2011 Annual Performance Goal		FY07	FY08	FY09	FY10	FY 2011
Establish at least 12 technology-related significant partnerships during FY 2011.		7IPP! Green	8IPP01 Green	9IPP1 Green	None	ST-11-13 Green
FY 2011 Performance Goal					FY 2011	
Complete 30 technology transfer agreements with the commercial and academic community through such mechanisms as licenses, software use agreements, facility use agreements, and Space Act Agreements per year.					3.4.1.2 Green	
FY 2011 Annual Performance Goal		FY07	FY08	FY09	FY10	FY 2011
Complete at least 30 technology transfer agreements during FY 2011.		7IPP2 Green	8IPP2 Green	9IPP2 Green	None	ST-11-14 Green
FY 2011 Performance Goal					FY 2011	
Successful application of Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) technologies into commercial products or services.					3.4.1.3 Green	
FY 2011 Annual Performance Goal		FY07	FY08	FY09	FY10	FY 2011
Greater than 35 percent of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase II technology projects awarded between 2004-2008 will be transferred into commercial products or services.		None	None	None	10IPP04 Green	ST-11-15 Red
Why NASA rated APG ST-11-15 Red: Based on NASA's current measurement method, NASA determined that it awarded 23.7 percent of SBIR/STTR projects (182 of 766) between 2004 and 2008 and had extended them past Phase II. NASA believes the numbers of commercialization successes are greater than the current methods indicate. To achieve commercialization, these projects used either NASA Phase III funds or an alternative source of non-NASA funding to develop the technology. Commercialization is a metric broadly defined by the SBA as a measure of the ability of SBIR/STTR contractors to successfully receive non-SBIR/STTR revenues for broad market, as well as other government applications, for technologies they developed under the SBIR/STTR programs. At NASA, this is defined as the sum of technology "infused" into NASA programs (metric 3.1.1.4), procured by other government agencies, and/or used in the commercial marketplace. The collection of non-NASA applications for this metric requires the voluntary sharing of information by SBIR/STTR contractors with NASA personnel. NASA continues to consider alternative methods of data collection that will lead to increasing accuracy in the measurement of commercialization successes. (See page 157 for the Performance Improvement Plan.)						
FY 2011 Performance Goal					FY 2011	
Document 40-50 of the most notable examples of successful transfer and commercialization of NASA-derived technology per year and publish in Spinoff annually.					3.4.1.4 Green	
FY 2011 Annual Performance Goal		FY07	FY08	FY09	FY10	FY 2011
Document at least 40 notable technology transfer successes in NASA's Spinoff publication.		None	None	None	10IPP01 Green	ST-11-16 Green
FY 2011 Performance Goal					FY 2011	
Document, coordinate, and prioritize Agency-level technology strategic investments to ensure NASA has a balanced portfolio of both near-term NASA mission (pull) technologies and longer-term transformational (push) technologies that benefit both Agency programs and national needs.					3.4.1.5 Green	

Strategic Goal 4

Advance aeronautics research for societal benefit.

As an industry, aviation contributes 1.3 trillion dollars to the Nation's economy and is responsible for ten million jobs in aviation related fields. Airlines in the U.S. transport over one million people daily, but during peak travel times the air traffic and airport systems in the United States are stretched to capacity. Environmental concerns, such as aircraft noise and emissions, limit increased operations and the expansion of airports and runways. NASA's Aeronautics Research Mission Directorate (ARMD) works to solve these critical challenges that affect the nation's air transportation system and growth of the economy, while improving safety of the system that is already the safest mode of transportation.

ARMD's four research programs conduct cutting-edge research at the fundamental levels and integrated systems levels to address these national challenges. That research supports current and emerging applications, as well as revolutionary concepts and technologies that could one day change the face of air transportation. ARMD's research portfolio is well aligned with the principles, goals, and objectives of the National Aeronautics Research and Development (R&D) Policy and Plan and directly supports the development of the Next Generation Air Transportation System, or NextGen. (Read more about NextGen plans at the Federal Aviation Administration (FAA) Web site <http://www.faa.gov/nextgen/>.)



This graphic shows conceptual aircraft designs developed in the Advanced Vehicle Concepts studies. The purpose of the studies was to analyze potential configurations and technologies designed to simultaneously reduce noise, emissions and fuel burn. (Credit: NASA)

ARMD's research is also enabled by its Aeronautics Test Program (ATP), which provides critical support to NASA's infrastructure needs (see Strategic Goal 5, page 133). ATP manages and makes strategic investments in the NASA-owned state-of-the-art ground test facilities and flight research assets to ensure ready access by NASA programs, other Federal agencies, and the private sector to test and evaluate research concepts and technologies.

ARMD fosters strong partnerships with other Government agencies, especially FAA and the Department of Defense (DoD). As a member agency of the multi-agency Joint Planning and Development Office (JPDO), NASA and partner agencies plan and coordinate the development of concepts and technologies required for NextGen.

Benefits

NASA's aeronautics research program is the Nation's most comprehensive civil aeronautics research and development effort. This technological superiority is a key enabler for the U.S. industry to continue its position as the world leader in the aviation sector that has been bringing a positive trade balance of over \$40 billion per year. The NASA-developed technologies are the DNA of almost all of the civil and military aircraft the U.S. aerospace industry has developed and marketed to date. NASA Aeronautics continues its tradition of developing and transferring innovative capabilities and technologies to U.S. industry and other government agencies, which in turn result in highly competitive U.S. products and superior capabilities that create and sustain high-technology, high-paying jobs boosting the U.S. economy. In the past couple of years, the U.S. aviation industry introduced highly competitive new aircraft and engine products into the global market. Below are a few examples of successful technology transfer NASA has made to the U.S. industry and to other government agencies.

Results from ARMD's fundamental research into high efficiency, low emissions combustion and light, high-temperature materials for jet engines from the 1990s and early 2000s have been incorporated by U.S. jet engine manufacturers, Pratt & Whitney (P&W) and General Electric (GE) in their next-generation aircraft engines (the Geared Turbofan (GTF) Engine and the LEAP-X engines, respectively). These engines feature more than 15 percent reduction in fuel burn and harmful emissions, and these competitive edges enabled P&W and GE to dominate the two global engine replacement programs: Boeing 737 MAX and the Airbus A320NEO. In the case of P&W, all new Bombardier C-Series and Mitsubishi Regional Jet selected the GTF engine as their launch product. As noted in the May 30, 2011, issue of *Time* magazine, job-creation associated with the P&W GTF engine is estimated to be in the hundreds of jobs per year in the high-paying manufacturing sector. The same competitive edges these engines present in decreased fuel burn, reduced emissions, and lower noise will directly benefit the flying public and communities adjacent to the Nation's airports helping to ensure the long-term viability of the U.S. air transportation system.

By addressing a current problem and making a timely transfer of the needed technology, we are helping our critical government partner for NextGen, FAA, to realize benefits in near term applications. NASA developed the Ground Delay Program (GDP) that combines National Weather Service real-time data with Air Traffic Control departure scheduling. FAA along with NASA's support conducted trials of this new capability at San Francisco Airport (SFO) this summer and demonstrated a significant reduction in ground delays due to morning fog compared with the current ground delay policy at SFO, which often leads to excessive and unrecoverable delays affecting the entire country.

NASA has open-sourced key data mining software for analyzing flight data recorder output through a collaborative Web site with over 300 members, known as DASHlink. Southwest Airlines (SWA) acquired sequenceMiner and Orca, two advanced anomaly detection techniques, through DASHlink. Early application of these techniques to data from 7200 SWA flights uncovered flight anomaly events that were not detected by SWA's existing analysis methods. Events flagged by these software tools are being added to SWA's daily operations review to improve operational performance. Southwest Airlines plans to incorporate these software tools into daily use to better manage their fleet of 305 planes that fly over 1,600 flights per day.

ARMD collaborates with universities for conducting cutting-edge, fundamental research with a built-in support for the science, technology, engineering and mathematics (STEM) education. For example, ARMD's NASA Research Announcements (NRAs) make significant investment in university research, which encourages participating undergraduate and graduate students to work with NASA researchers and its industry partners. NASA Aeronautics Scholarship Program also provides tuition support and funds student recipients to spend a summer working with NASA researchers at NASA Research Centers. These direct interactions and hands-on experience have been helping to inspire students toward future careers in the STEM professions.

Risk to Achieving Strategic Goal 4

NASA purposely pursues very challenging and high payoff aeronautics research goals to bring about revolutionary advancement, not incremental improvement, in technologies and concepts. With inherently high-risk research, the potential for not meeting any specific research metric is always present. NASA is still committed to performing such research, and seeks to ensure that our research—even for those cases where the intended results were not achieved—provides valuable knowledge. These risks are mitigated by making certain that NASA's work is relevant to national needs, closely coordinating and collaborating with external partners, and ensuring technical excellence and rigorous technical and program management.

Outcome 4.1

Develop innovative solutions and advanced technologies through a balanced research portfolio to improve current and future air transportation.

NASA, through the [Aeronautics Research Mission Directorate \(ARMD\)](#), plays a key role in the discovery and development of the innovative solutions and advanced technologies required for the Next Generation Air Transportation System (NextGen). This includes pursuing technologies that are in their infancy today, developing the knowledge necessary to design radically new aviation systems, and enabling efficient, high-confidence design and development of revolutionary vehicles. These improvements must take place without compromise to the current safety record of the aviation industry.

Each of ARMD's fundamental aeronautics research programs contribute significantly in addressing the challenges of the current and future air transportation system. Below are summaries of their major contributions to this outcome for FY 2011.

Developing advanced technologies to improve air transportation system safety

The extremely high safety record of the National Airspace System (NAS) is a credit to the on-going vigilance of operators, manufacturers, and regulators and past investments in technology. But even with very low accident rates, the United States always strives to improve this record, and NASA contributes to this continuous improvement through innovation to meet the remaining and emerging safety challenges. ARMD's [Aviation Safety Program](#) develops innovative algorithms, tools, concepts, and technologies that will improve the safety attributes of current and future aircraft operating in the NAS, identify and control emerging hazards, and overcome aircraft safety-related barriers that could impede full realization of NextGen.

NASA explores damage-tolerant materials to improve aircraft safety

This fiscal year, researchers in the Aviation Safety Program successfully demonstrated self-healing concepts to mitigate damage in aircraft structural elements, helping to improve aircraft safety.

Initiation and propagation of damage generally results in failure of aircraft structural components. Additionally, typical structural repairs often result in damaging practices, where material is ground away and holes are drilled to secure patches, which can act as new sites for damage. The proposed self-healing system provides a non-intrusive means to mitigate damage and is a significant foundation for future self-healing systems.

Demonstration results have shown the ability to mitigate fatigue crack spread in metals and to mitigate the effects of impacts on compressive strength in composites. For metals, a heat-activated self-healing material is drawn into fatigue cracks. The material successfully reduced the crack tip driving force of two aerospace materials (aluminum and titanium alloys), dramatically slowing the spread of the crack. For composites, the program developed a carbon fiber reinforced composite with a commercially available thermoplastic resin, which self-heals after ballistic impact and through-penetration. A healing effect was demonstrated in the developed composite materials by heating these materials under pressure. These capabilities suggest that a healing system can be scaled up to provide self-healing to damaged structural aircraft components.

Work supporting this research and other program accomplishments was done in close cooperation with the program's many partners from industry, academia, and other Federal agencies. The program also published numerous technical papers, gave presentations at conferences, and worked with partners to transfer key technologies.

Developing innovative solutions and technologies to enable the NextGen

The [Airspace Systems Program](#) addresses the fundamental air traffic management research needs of increasing capacity, improving efficiency, and reducing the environmental impact of aviation in NextGen in collaboration with its partners in government, industry, and academia. The program works to directly benefit the flying public by moving key concepts and technologies from the laboratory into the field to facilitate the transfer of technology to end users. Concept simulations and field trials in real flight environments of NASA developed technologies have demonstrated the potential annual savings of tens of millions of dollars to airspace users through reduction in flight delays and fuel usage.

NASA continues research to improve air traffic management to make air travel more efficient for the benefit of the flying public

Researchers in the Airspace Systems Program conducted work in tools and methods for in-flight “flow-based trajectory management” in the NextGen. Flow-based Trajectory Management (FBTM) is a process for solving local airspace problems by modifying flight paths, or trajectories, of one or more aircraft. These operations provide a practical way to maintain efficient operations in the face of changing local and downstream conditions. Solving the technical challenge of managing in-flight trajectories that extend beyond currently available planning horizons provides one step toward accommodating increasing capacity in the airspace.

The concept of FBTM has evolved through a series of studies that began in 2006 and culminated this year in a study completed by the joint NASA–Federal Aviation Administration (FAA) FBTM Research Transition Team (RTT). NASA uses the joint agency RTT to conduct research and field-trials to accelerate acceptance of new air traffic management procedures. For the study, the RTT modified current air traffic management procedures to distribute FBTM responsibilities within a “planning team” comprised of traffic management and area supervisors.

The study demonstrated that FBTM is an effective method for managing future aircraft operations. The RTT successfully managed air traffic levels 30 percent greater than today’s level. FBTM also can be integrated effectively into today’s operations without additional resources. The RTT provided simulation results and tool requirements to FAA as technology transfer to inform FAA acquisition planning. The results also inform 10 out of 50 Operation Improvements as described in the FAA’s NextGen Implementation Plan (released March 2011 and available at http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf). The study is an example of successfully transitioned research results from NASA to FAA and government collaboration using the RTT model. Read more about the study in a paper produced by the Joint Planning and Development Office: http://www.jpdo.gov/library/20110712_JPDO_Paper_FBTM_Result_v1.4.pdf.



The NASA Ames Airspace Operations Laboratory is a high-fidelity simulation environment for prototyping and testing advanced air traffic management concepts. The laboratory provided the environment to develop the FBTM tools, which support situation assessment (e.g., load tables, load graphs, traffic display with weather and filters), multi-trajectory trial planning, and ground-to-ground coordination of plans and clearance requests. These tools can be configured for traffic management units, multi-sector planning, or area supervisor positions. (Credit: NASA)

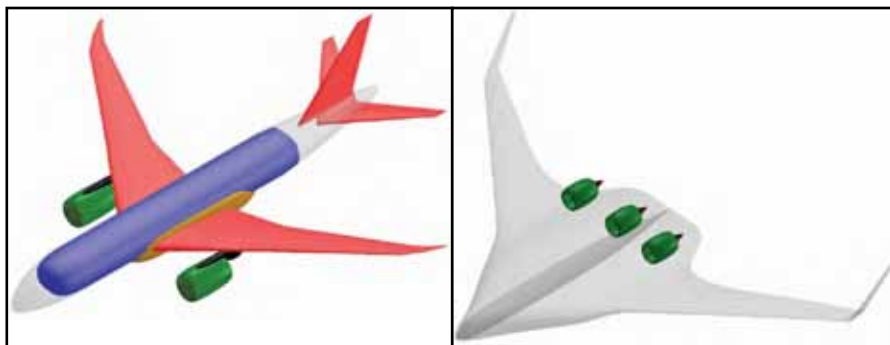
Developing tools, technologies, and knowledge that improve performance and new capabilities for future air vehicles

The Fundamental Aeronautics Program seeks to enable a future where a variety of advanced aircraft improve the flexibility, efficiency, and environmental impact of air travel by developing tools, advanced technologies, and scientific knowledge necessary for the design of new types of vehicles. The program conducts research on topics such as advanced vehicle configurations and concepts, lighter, stronger materials and structures, fuel efficient and less polluting propulsion systems, advanced concepts for increasing lift and reducing drag, advanced computational tools and capabilities, and modeling and simulation for efficient future air vehicle design.

Advances in future air vehicles demand environmentally sensible and innovative aeronautics technologies and concepts that demonstrate significantly better performance and higher fuel efficiencies, and reductions in noise and emissions across different flight regimes, such as subsonic, supersonic, and hypersonic. The Fundamental Aeronautics Program, through its four projects—Subsonic Fixed Wing, Subsonic Rotary Wing, Supersonics, and Hypersonics—conducts in-house foundational and cross-cutting research across a broad range of research topics to meet these technology goals.

NASA studies methods to enable advances in future vehicles

In FY 2011, researchers completed and validated the second generation of a multi-disciplinary analysis and design toolset used to evaluate the trades between noise, emissions, and performance of future subsonic fixed wing aircraft. Predictions of both conventional (e.g., a Boeing 737-800 used for commercial transportation) and unconventional (e.g., a hybrid wing body) aircraft performance—noise, emissions, fuel-burn, takeoff and landing performance, and aircraft weight—compared well to second generation validation targets. These new tools are used to develop new configurations and assess the introduction of new technologies that allow significant improvements in performance for future



The figure on left is a conventional tube and wing aircraft configuration and the figure on the right is an unconventional aircraft configuration such as a hybrid wing body. (Credit: NASA)

aircraft. These tools also are used to help guide future research to help select and develop the technologies that will have the most impact on an integrated design.

NASA research in subsonic rotary wing focuses on speed and range increases, payload capacity, noise reduction, propulsive efficiency, and rotorcraft unique technologies to enable development of new configurations that enhance mobility of the future air transportation system. This includes maturing technologies—e.g., technologies related to icing, crashworthiness, condition based maintenance, low noise flight operations, damage mitigation—needed for civil, commercial operations.

In FY 2011, researchers focused on developing methodologies to certify crashworthy designs by analysis, which minimizes the need for costly full-scale testing. The program used test data obtained from full scale crash tests of a MD-500 helicopter, conducted in December 2009 and March 2010, to calibrate and validate finite element models that contained detailed representations of airframe, seats, occupant, and external energy absorbers. Results and comparisons were very encouraging: the models predicted the pilot floor acceleration response within ± 10 percent of the target.

The significance of this result is that survivability envelopes for a range of velocities, attitudes, and terrains can be developed from both tests and system-integrated models with a higher degree of confidence. As the technology evolves to efficiently incorporate more modeling and simulation into the design process, next generation rotorcraft will contain more crashworthy features without sacrificing weight and performance.



The images at left show a comparison between a full-scale MD-500 helicopter crash test (right) and a finite-element model representation of the same event. NASA used test data from instrumentation and video photogrammetry to calibrate and validate the finite element models. (Credit: NASA)

Outcome 4.1					
Develop innovative solutions and advanced technologies through a balanced research portfolio to improve current and future air transportation.					
FY 2011 Performance Goal					FY 2011
Transfer knowledge to the aviation community to better manage safety in aviation.					4.1.1.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Demonstrate scalable anomaly detection on heterogeneous data.	None	8AT04 Green	9AT1 Green	10AT01 Green	AR-11-1 Green
Demonstrate self-healing material concepts to mitigate damage in structural elements.	None	8AT04 Green	9AT1 Green	10AT01 Green	AR-11-2 Green
FY 2011 Performance Goal					FY 2011
HPPG: Increase efficiency and throughput of aircraft operations during arrival phase of flight.					4.1.2.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Conduct simulations of initial tactical conflict prediction and resolution advisory functions to address reduction in false alerts and increase in time to detect a loss of separation in terminal operations.	None	8AT05 Green	9AT5 Green	10AT05 Green	AR-11-3 Green
Specify operational requirements for performing Multi-Sector Planning (MSP) functions in the mid-term, including technical and conceptual requirements, with consideration of how requirements might change as the National Airspace System (NAS) evolves towards NextGen.	None	None	None	10AT06 Green	AR-11-4 Green
HPPG: Report on Human-In-the-Loop (HITL) Simulation and model results.	None	None	None	10AT14 Green	AR-11-5 Green
FY 2011 Performance Goal					FY 2011
Deliver tools, technologies, and knowledge that can be used to more efficiently and effectively design future air vehicles and their components that overcome national performance and capability challenges.					4.1.3.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Achieve validated accuracy for conventional and unconventional aircraft, respectively, for nitrogen dioxide (NOx), takeoff and landing performance, cruise performance, take-off gross weight (TOGW), and noise.	None	8AT07 Green	9AT7 Green	10AT07 Green	AR-11-6 Green
Demonstrate the ability to predict the effect of impact dynamics on a full-scale airframe within 10 percent of measured acceleration.	7AT4 Green	8AT09 Green	9AT8 Green	10AT08 Green	AR-11-7 Green
Demonstrate the ability to optimize a baseline aircraft design to simultaneously achieve high cruise efficiency and low sonic boom using Multidisciplinary Analysis & Optimization (MDAO) with a two-week cycle time.	None	8AT11 Yellow	9AT9 Green	10AT09 Green	AR-11-8 Green
Validate NASA propulsion Computational Fluid Dynamics (CFD) codes using Hypersonic International Flight Research Experimentation (HIFiRE) scramjet flight data and ground-based test results.	None	None	9AT10 Yellow	10AT10 Yellow	AR-11-9 Yellow
Why NASA rated APG AR-11-9 Yellow: This annual performance goal was not met, in this fiscal year, and is expected to be accomplished in the June/July 2012 timeframe. To validate the Computational Fluid Dynamics (CFD) code, NASA is gathering this data on the Hypersonic International Flight Research Experimentation (HIFiRE) #2 vehicle's scramjet, while in flight. The Air Force has moved the date for the HIFiRE #2 vehicle launch until Summer 2012. (See page 174 for the Performance Improvement Plan.)					

Outcome 4.2

Conduct systems-level research on innovative and promising aeronautics concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.

To complement NASA's investment in fundamental research, the Integrated Systems Research Program (ISRP) conducts research on integrated system-level vehicle and airspace system concepts and technologies, and demonstrates their intended and integrated benefits in a relevant environment. By doing so, one of the ISRP's main goals is to accelerate the transition of aeronautics research and development results, including NextGen technologies, to users in industry and government. Research is coordinated with the Aeronautics Research Mission Directorate's (ARMD's) fundamental research programs and with relevant efforts by other Federal agencies and industry.

Currently, ISRP research is focused on technologies to reduce the environmental impact of aircraft (in terms of local and global emissions, local air quality, and noise) and integration of Unmanned Aerial Systems (UAS) into the National Airspace System (NAS). The United States is highly dependent on the health of the aviation and aerospace industry as it contributes to economic activity via the transport of passengers and cargo domestically and abroad and to homeland security. The ability to transport people and goods point-to-point domestically and internationally is critical to all levels of the economy. Furthermore, it is essential that this ability be realized with flexibility, affordably, and in an environmentally responsible manner.

ISRP's Environmentally Responsible Aviation (ERA) project focuses on selecting vehicle concepts and technologies that can simultaneously reduce aircraft fuel burn, noise, and emissions. Today's aircraft already benefit from NASA investments in aeronautical research that have yielded improved fuel efficiencies, lowered noise levels, and reduced harmful emissions. Although substantial progress has been made, much more needs to be done. The Nation's air transportation system is expected to expand significantly within the next two decades. Clearly there is a potential adverse impact from this expansion on the environment. The ERA project invests in technologies with the potential to substantially reduce the environmental impact of aviation.

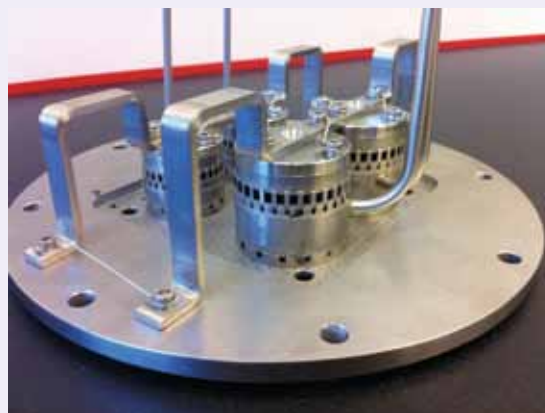
Research in the ERA project is focused in three main areas: Airframe Technology, Propulsion Technology, and Vehicle Systems Integration. Together, they help industry enlarge the viable trade space—the degree to which performance objectives can be traded against each other to achieve the best overall value—to help in designing and building the most environmentally efficient commercial aviation vehicles.

NASA helps make aircraft more environmentally friendly

During FY 2011, research in the propulsion technology area focused on significantly reducing harmful nitrogen oxide (NOx) emissions while reducing fuel burn in aircraft engines. This involved the development and demonstration of new aircraft engine combustor concepts that efficiently mix the fuel and air to maintain a stable combustion process and minimize the formation of NOx emissions.

NASA worked collaboratively with industry to develop and test a variety of advanced concepts. Both Pratt & Whitney and GE Aviation demonstrated several new combustor concepts that have the potential to reduce NOx emissions by as much as 75 percent relative to aircraft flying today. Over the next several years, NASA will work with these companies to mature these advanced combustor concepts and assess the feasibility of incorporating them into future aircraft engines.

NASA and its partners will use NASA facilities that simulate aircraft engine conditions to validate the combustor performance, operability, and reduced emissions at conditions consistent with the full range of aircraft engine power settings. Combustor testing is expected to demonstrate a reduction of landing and take-off NOx emissions to



The Counter Rotating External Staged Swirler (CRESS) concept is one of two Lean Direct Injection concepts developed by Pratt & Whitney that achieved greater than 75 percent NOx reduction in a flامتube rig at low power settings. (Credit: NASA)

75 percent below the goals recommended at the sixth meeting of the Committee on Environmental Aviation Protection, which helps formulate standards and recommended practices on aircraft noise and aircraft engine emissions. In addition to meeting the emissions goals, the combustor must operate at conditions consistent with an aircraft/engine architecture designed to reduce fuel burn by 50 percent from current state-of-the-art aircraft and have the ability to use conventional, as well as synthetic, jet fuels.

Outcome 4.2						
Conduct systems-level research on innovative and promising aeronautics concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.						
FY 2011 Performance Goal					FY 2011	
Reduce technical risk by conducting research at an integrated system-level on promising aeronautical concepts and technologies in a relevant environment.					4.2.1.1 Green	
FY 2011 Annual Performance Goal		FY07	FY08	FY09	FY10	FY 2011
Optimize fuel injector designs through flametube and/or sector tests and demonstrate their performance in meeting futuristic aircraft emission goals.		None	None	None	None	AR-11-10 Green
Uniform and Efficiency Measures						
	FY07	FY08	FY09	FY10	FY 2011	
Deliver at least 86 percent of on-time availability for operations and research facilities.	7AT8 Yellow	8AT17 Yellow	9AT12 Green	10AT13 Green	AR-11-12 Yellow	
Why NASA rated APG AR-11-12 Yellow: The on-time availability of the operations and research facilities managed by the Aeronautics Test Program, was 80 percent, slightly less than the targeted 86 percent availability. NASA did not meet its target, primarily due to the downtime, introduced with the failure of subsystems in two facilities at the Glenn and Langley Research Centers. At Glenn Research Center, the 8 foot by 6 foot Wind Tunnel, had unscheduled downtime to repair the Open Rotor Propulsion Rig (ORPR) forward balance, which has resulted in rescheduling testing into FY 2012. At Langley Research Center, the 14 foot by 22 foot Wind Tunnel experienced unscheduled downtime due to issues with the main drive lubrication system and the motor generator set. (See page 174 for the Performance Improvement Plan.)						

Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.

The supporting capabilities, services, and infrastructure that enable NASA's missions are naturally a strategic imperative, but this is the first time that NASA has had a strategic goal dedicated to mission support. This addition demonstrates NASA's acknowledgement of the challenges it currently faces in the mission support arena, as well as a commitment to performance achievement and improvement.

Successful mission support requires integration of all elements across organizational and functional boundaries and application of an Agency-wide view in making investment decisions. The linkage between NASA's mission portfolio and mission support elements must be understood through analyses to assess risks, opportunities, and efficiencies, and then acted upon. Integration requires a strong governance structure to harmonize policies and business practices, mitigate conflicting requirements, and enforce the internal controls that oversee the effectiveness, efficiency, reliability, and compliance of NASA's operations. NASA's mission support governance structure includes a decision-making process guided by short- and long-term considerations to create a balanced and integrated mission support portfolio. NASA uses an approach that is requirements-oriented (aligned with missions and external requirements) to provide basic Center operations and an optimal mission support environment.

Institutional capabilities encompass a broad range of essential technical and non-technical corporate functions for the entire Agency. The Agency's program capabilities include managing the scientific and engineering workforce and maintaining NASA-unique facilities, equipment, tools, and other required resources. For FY 2011, NASA focused its performance measurement on major efforts, like Shuttle workforce transition, activities that will affect much of the Agency, and important ongoing capabilities maintenance. A few of these activities, like launch services, are managed by mission directorates, but directly contribute to capabilities and infrastructure that support NASA's missions.

Benefits

NASA's program and institutional capabilities ensure that NASA is able to fulfill its commitments to all stakeholders, while providing a safe and efficient working environment. Some of the benefits of these capabilities include the following:

- Safety and mission assurance capabilities protect the workforce and Agency assets, underpinning the success of all technical activities.
- Information, infrastructure, and security capabilities support the productivity of NASA's scientists and engineers.
- Launch, rocket propulsion testing, space communications, and aeronautics test services provide key capabilities for the technical activities of NASA and its partners.
- Capabilities in human capital management, finance, procurement, occupational health and safety, equal employment opportunity and diversity programs, and small business programs ensure that a well-qualified workforce representing a range of backgrounds and experience is available to meet Agency needs.

NASA also is addressing strategic themes such as affordability and sustainability for longer-term planning of program and institutional capabilities. Components of these themes include "green" initiatives and energy efficiency, workforce alignment and readiness, diversity, improved acquisition, and eliminating Center duplication of capabilities.

Risks to Achieving Strategic Goal 5

Meeting Changing Facilities Requirements. An ongoing challenge is managing current facilities resources and capabilities and anticipating changes in needs. An important component of facilities management is updating, replacing or eliminating aging or obsolete facilities. The Agency is developing multi-year Center plans and an integrated Agency Master Plan, and is aggressively managing to reduce facility costs and improve overall capabilities. NASA seeks optimal solutions in how it conducts operations, often leveraging resources and opportunities offered by Agency partners or seeking products and services from commercial sources.

Achieving and Sustaining State-of-the-Art Technologies for Institutional Capabilities. To realize future cost, schedule, and quality improvements, NASA must stay current with technological progress. The Agency actively monitors the research and development work of other Federal agencies, industry, academia, and other nations. NASA conducts studies and planning activities Agency-wide to determine the potential mission applicability of emerging and maturing technologies. New tools, processes, and technologies improve capabilities and scientific returns, but cannot be predicted in advance. Institutional management processes must be sufficiently robust to maintain NASA research, testing, and operations capability, while allowing the Agency to adopt and benefit from the latest technologies and innovations. Recent examples include advancements in alternative fueling for fleet vehicles and in water reuse projects.

Managing a Distributed Infrastructure Base. NASA's program management is distributed across numerous mission areas and geographically separated Centers and facilities. This presents challenges in implementing a consistent and cost-effective set of processes, systems, and tools. Differences in local and state policies, zoning and environmental regulations, and even energy costs impact the Agency's ability to create and implement a uniform approach. At every Center and facility, NASA works proactively and cooperatively with local, state, and Federal regulatory entities to mitigate possible negative impacts before policies or rules are finalized. By adhering to a common set of values and operating principles, but allowing for flexibility in implementation, NASA minimizes risk to missions and positions the Agency for success in future endeavors.



NASA's Ames Research Center and the Department of Energy (DOE), at the Lawrence Berkeley National Laboratory are collaborating on technologies and processes for what may be the "greenest," highest-performing building in the Federal government.

Originally developed for aerospace applications, NASA intelligent system software will be installed in the new building, called Sustainability Base (shown in the photo), by Ames engineers. These NASA-developed control and Integrated Systems Health Management (ISHM) technologies will be an integral part of the building. To help integrate these "smart system" technologies, the Building Technologies Department at Berkeley Lab developed a Building Information Model (BIM) to serve as the repository for the building's systems information during its life cycle. Using data from the BIM, Berkeley Lab developed an energy-performance simulation model to optimize the building's energy operations. (Credit: NASA)

Outcome 5.1

Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.

NASA has a skilled, competent, and dedicated workforce. They are passionate about their work, and they bring many dimensions of diversity, including ideas and approaches, to make their teams successful. To continue the successful conduct of missions over the next 10 to 30 years, NASA must broaden, maintain, and sustain its diverse workforce with the right balance of skills and talents. The [Office of Human Capital Management](#), [NASA Education](#), and the [Office of Diversity and Equal Opportunity](#) work collaboratively to identify future needs and to identify gaps and potential shortfalls in skills. They also cooperatively plan Agency-level participation in new employee recruitment efforts.

NASA has established a Diversity and Inclusion Framework to increase the diversity of the workforce and the overall inclusiveness of the work environment. The framework takes the Agency beyond a focus on equal employment opportunity (EEO) compliance to policies and practices designed to enhance innovation, creativity, and employee engagement. Complementary to its diversity and inclusion efforts, the Agency works aggressively to identify and eliminate environmental factors that can diminish trust, impair teamwork, compromise safety, and ultimately undermine excellence. NASA conducts an annual self-evaluation as part of the Model EEO Plan, which is designed to identify and remove barriers to individual and team success. NASA continued to make progress in its efforts to become a model agency for EEO. For example, NASA continued to successfully implement programs designed to proactively prevent discrimination, such as conflict management, anti-harassment, and the provision of reasonable accommodations.

Below are some of the activities conducted during FY 2011 by the Office of Human Capital Management, the Office of Education, and the Office of Diversity and Equal Opportunity in support of this outcome.

Creating a workforce with top technical and business management competencies

Dedication to the Shuttle and NASA

Workforce efforts in 2011 emphasized safe fly-out of the Space Shuttle and transition efforts to support the Agency direction in alignment with the NASA Authorization Act of 2010. With the successful completion of [STS-135](#) on July 21, 2011, NASA demonstrated the ability to identify, cultivate, and sustain a workforce with technical and business management competencies to safely complete the Space Shuttle manifest and prepare the [International Space Station](#) for its post-assembly operations and utilization phase.

NASA had asked the Shuttle operations workforce—both civil service and contractors—to stay through the end of the [Space Shuttle Program](#) to safely complete the Shuttle's final mission. NASA and the Space Shuttle prime contractors worked closely together to develop and implement a range of tools and strategies to help safely manage operations through retirement. These strategies and tools included retention pay for the contractor workforce, developmental opportunities (technical and leadership), workforce sharing (matrix management, rotations, job sharing), communications, and recognition. NASA also implemented regular surveys of the Shuttle workforce and monitoring of attrition rates, which remained very low in 2011.

Moving on from Shuttle

To support transition of the workforce to NASA's future direction that aligns with the NASA Authorization Act of 2010, NASA conducted multiple job seeking training sessions (e.g., resume writing, interviewing, use of social media), as well as career counseling sessions for the workforce. NASA also continued management of the Space Shuttle Transition Liaison Office transition activities, including building relationships with other Federal partners like the Departments of [Commerce](#) and [Labor](#), conducting two face-to-face meetings with affected Centers and communities, conducting two Federal government virtual job fairs, and partnering with the [Office of Personnel Management \(OPM\)](#) to conduct a Federal career fair at [Kennedy Space Center](#) on July 26, 2011 to provide opportunities for displaced contract workers. NASA's Office of Human Capital Management developed, deployed, and implemented a Workforce Transition Tool that provides the ability to track, plan, and status the impacted Shuttle employees as they transition to support other NASA technology development and space activities.

The NASA Human Resources team established a Kennedy Space Center Workforce Transition Office (WTO) in partnership with Brevard Workforce, a regional public–private partnership, to help facilitate a successful workforce transition across the Center. It is staffed by NASA Human Resources professionals who are available to offer guidance to employees—both civil servants and contractors—regarding Federal employment. Services include assistance with understanding Federal job announcements, applying for Federal employment, writing a Federal resume, interviewing tips and techniques, and personal transition referral services.

Getting employees' views of NASA diversity and inclusion

At the same time, NASA made great strides with its diversity and inclusion efforts during FY 2011. The Agency deployed a survey to all employees designed to establish a baseline for employee viewpoints on diversity and inclusion related matters such as equitable allocation of career enhancing opportunities, facilitation of diverse inputs into strategic planning and decision-making, and effective communication between management and employees.

Some of the highlights of the 2010 Diversity and Inclusion Assessment Survey's findings included the following:

- Most respondents indicated that NASA policies promote fair treatment of employees (83 percent) and that NASA values employees with varied backgrounds and experiences (75 percent).
- Overall, a high percentage of employees gave positive responses regarding NASA creating a diverse and inclusive work environment, with high levels of agreement for fostering mutual trust and respect in the workplace (76 percent), valuing employee contributions (75 percent), and providing a supportive environment for every employee (72 percent).
- A high proportion of respondents reported feeling like a valued employee at NASA (72 percent) and that they could recommend NASA as a good place to work (79 percent).

Among the findings pointing to the need for additional steps to enhance diversity and inclusion at NASA were the following:

- Only 60 percent indicate that NASA is effective at educating employees on how diversity and inclusion foster innovation. Further, 68 percent of respondents reported that diversity and inclusion led to innovative ideas, yet only 45 percent agree that NASA uses diversity and inclusion effectively to increase workforce productivity, and only 32 percent disagree with the statement that NASA's efforts to achieve workforce diversity and inclusion sometimes lead to workplace problems.
- Less than half (49 percent) of respondents agreed that supervisors and managers help employees to recognize biases that foster workplace discrimination or exclusion.

NASA as a Model Equal Employment Opportunity Workplace

In its continuing efforts to become a model organization for EEO, NASA set an ambitious agenda in FY 2011 for workforce participation. Currently, NASA is at or above the relevant civil labor workforce participation rates for women and most race/ethnicity groups. Additionally, the Agency's statistics for individuals with targeted disabilities also are consistent with government-wide numbers.

NASA's goal to be a model for EEO requires continuous and aggressive improvement efforts. The Model EEO Plan contains 57 actions, which grew out of the Agency's self-assessment of where it stands in its efforts to better ensure a workplace environment conducive to every employee reaching his or her full potential. To meet this ultimate objective, NASA designed the plan's actions to enhance recruitment, retention, and professional development opportunities for all employees and all EEO groups. Consistent with this approach, NASA sought to complete 40 of the 57 actions in the first year of the plan alone. The Agency fell short of its targets in FY 2011, but will continue to improve the plan and work toward making the work environment increasingly free of barriers.

Effective labor management

To enable institutional capabilities and in support of substantive mission transition, NASA focused significant effort in restructuring the labor funding and associated processes. In FY 2011, NASA's Office of Human Capital Management led the effort and successfully implemented labor funding and full time equivalent (FTE) planning structures, created a new workforce process for the labor formulation process used to support the Planning Programming Budgeting and Executing (PPBE) formulation cycle, and developed a new labor execution approach called GOLD (Governance of Labor Distribution). These capabilities help ensure that moving forward all NASA workforce is assigned to NASA missions, and

by allocating FTE and dollars by mission and center, ensures that there are no unfunded FTE. These workforce planning structures and processes provide NASA a well-documented and clear foundation, which programs and institutional capabilities can use to align the workforce to successfully conduct NASA's missions.

NASA focused on communications to enhance NASA's inclusive work environment. In support of communications in 2011, NASA sustained effective labor-management dialogues through the Labor Management Forum (LMF). NASA successfully conducted six LMFs in 2011. These were held on November 19, 2010 and on January 25, March 10, May 26, July 22, and September 22, 2011. The topical areas addressed include usage of term appointment authority, a review of the Agency performance management process to address concerns about discrimination, and a discussion of line management and program management communication issues.

Building tomorrow's workforce by attracting students to STEM-related disciplines

Attracting student participation that is as diverse as the Nation

NASA assists minority institutions and faculty through multi-year research grants and provides scholarships, internships, mentoring, and tutoring to underserved and underrepresented students. Through the Minority University Research and Education Program (MUREP), students attend Minority Institutions, including Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Hispanic-Serving Institutions, and participate widely in NASA's research and education programs and its overall Mission.

Many of these efforts also have had notable success in attracting women. Through participation on the White House Council for Women and Girls, NASA takes into account the needs of women and girls in the policies the Agency drafts, as well as the education programs that are supported. Having greater numbers of female, underserved and underrepresented students participating in NASA programs supports the entry of these students into the scientific and technical workforce as well as their pursuit of advanced science, technology, engineering, and mathematics (STEM) degrees.

The NASA higher education program that receives the largest share of Agency education funding, and thus serves the largest number of higher education students nationwide, is the National Space Grant College and Fellowship Program (Space Grant). The NASA Space Grant Program Office has an established expectation of 40 percent female participants among each of its 52 consortia. Additionally, the Space Grant consortia are accountable for improving and maintaining the participation of underserved and underrepresented students in their programs. State-specific goals for underserved and underrepresented participation are established for each Space Grant consortium according to National Center for Education Statistics higher education enrollment figures. The cultivation of diversity is both a management philosophy and core value for all NASA education efforts. Diversity of the skills and talents needed in its future workforce is critical to NASA's success. Potential at both the individual and organizational levels is maximized by fostering awareness, understanding, and respect for individual differences. The knowledge, expertise, and unique background and life experiences, including the race, ethnicity, and gender, of each individual serve to strengthen the Agency.

Global Climate Change Education at Minority Serving Institutions

In June 2011, MUREP awarded \$7.2 million in cooperative agreements to 14 minority-serving organizations across the United States to enhance learning through the use of the Agency's Earth Science resources. The winning proposals illustrated innovative approaches using NASA content to support undergraduate teaching and learning, with particular emphasis on engaging students using NASA Earth observation data, Earth system models, as well as providing climate-related research experiences for teachers and undergraduate students.

Minority Innovation Challenges Institute

Also in June, the NASA Minority Innovation Challenges Institute (MICI) announced opportunities for minority serving institutions to apply for a \$5,000 grant to enter the University Student Launch Initiative (USLI) or Lunabotics Mining Competition.

MICI is designed to inspire minority undergraduate students to pursue advanced degrees and careers in science, technology, engineering and math disciplines critical to NASA's future missions. USLI challenges students to design, build, and launch to an altitude of one mile a reusable rocket with a scientific or engineering payload. The project engages students in scientific research and real-world engineering processes with NASA engineers at NASA's Marshall Space Flight Center in Huntsville, Alabama. The Lunabotics competition, which takes place at NASA's Kennedy Space Center in Florida, challenges students to design and build remote controlled robots that can excavate simulated lunar dirt. During the event, the teams' designs, known as lunabots, will go head-to-head to determine which one can collect and deposit the most dirt within 15 minutes.

Tribal College and University Project (TCUP)

In 2011, MUREP's TCU project provided NASA engineering expertise to help establish an accredited Bachelor of Science degree in Computer Engineering at Salish Kootenia College in Montana, the first four-year engineering program offered by any of the 36 tribal colleges in the United States. Additionally, the project has helped remove many of the barriers to Native American student participation in NASA competency building and research opportunities by providing an "externship" program in which the initial three weeks of the program are held at a tribal college (United Tribes Technical College in North Dakota). The remaining seven weeks are conducted at the home institutions of the Tribal College students and faculty mentors. In FY 2011, 36 students and faculty from nine TCUs participated.

Outcome 5.1					
Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.					
FY 2011 Performance Goal					FY 2011
Define and build the workforce skills and competencies needed for the Agency's future directions in technology development and deep space exploration.					5.1.1.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Seventy-five percent or more of Shuttle workforce has been realigned for new Agency needs..	None	None	None	10WF06 White	AMO-11-1 Yellow
Why NASA rated APG AMO-11-1 Yellow: NASA did not meet the target for this annual performance goal as a result of Congressional budget action. The addition of a Shuttle mission and delays in the mission manifest resulted in a slower than planned transition of workforce from the Space Shuttle Program. Additionally, the year-long Continuing Resolution significantly delayed the start of new programs to which NASA planned to transition the Space Shuttle workforce. (See page 184 for the Performance Improvement Plan.)					
Twenty percent or more of annual recruitments will be through the early career hiring initiatives.	None	None	9ED5 Green	10ED04 Yellow	AMO-11-2 Green
FY 2011 Performance Goal					FY 2011
Build skills across all levels of the workforce through Leadership Development Opportunities.					5.1.1.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Evaluate current state of Agency leadership training and development and publish findings and recommendations in a comprehensive report to guide future program direction.	None	None	None	None	AMO-11-3 Green
Seventy-five percent of the Agency's leadership training and development programs include "leading through transformation" content.	None	None	None	10WF04 Green	AMO-11-4 Green
FY 2011 Performance Goal					FY 2011
Achieve and sustain an effective labor-management dialogue.					5.1.1.3 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Identify and address at least three significant labor-management challenges identified during the year during periodic Agency-led Labor Management Forums.	None	None	None	None	AMO-11-5 Green
FY 2011 Performance Goal					FY 2011
Adopt and respond to innovative employee feedback mechanisms.					5.1.1.4 Green

FY 2011 Annual Performance Goal	FY 07	FY08	FY09	FY10	FY 2011
Identify and address at least two topics that employees identified in the latest Federal Employee Viewpoint Survey.	None	None	None	None	AMO-11-6 Yellow
Why NASA rated APG AMO-11-6 Yellow: This annual performance goal was not met. Many of the planned activities were completed but several have been delayed into FY 2012. Specifically, the identified areas to be addressed, and their corresponding action plan, are as follows: 1) Continue focus on teamwork/working together to ensure mission success. Planned actions included continual monitoring of Shuttle work-force concerns through regular surveys; and instituting a team-building focus in Agency leader development programs. The activities toward this topic were completed in this fiscal year. 2) Ensure that recognition and rewarding of employees is fair, consistent, and based on results-oriented performance. The planned actions included educating and training supervisors, through Agency supervisory training courses; and implementing recommendations for enhancing the Agency's Honor Awards Program. Both of these planned actions were delayed into FY 2012. This years funding level removed the option for conducting further Agency supervisory courses in FY 2011. Additionally, the development of new policies surrounding the Agency Honor Awards Program, is taking more time than planned, resulting in a delay until FY 2012. (See page 182 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
Establish and maintain a workplace environment free of illegal discrimination, harassing conduct, and retaliation for Equal Employment Opportunity (EEO) activity and that provides reasonable accommodations to individuals with disabilities.					5.1.1.5 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete FY 2011 actions described in the NASA Model Equal Employment Opportunity (EEO) Agency Plan.	None	None	None	10WF01 Green	AMO-11-7 Yellow
Why NASA rated APG AMO-11-7 Yellow: NASA made significant progress on many of 57 activities, contained in the Model EEO Agency Plan for FY 2011-2013, which have efforts in fiscal year 2011, but did not complete all the planned actions. NASA sought to complete 40 of the 57 actions in the first year of the Plan alone. NASA completed 14 of these actions (35 percent). In addition, NASA completed five actions not targeted for completion until FY 2012. Of the other actions targeted for completion in FY 2011, NASA has partially completed 19 (48 percent). NASA has completed key actions related to the Agency's Anti-Harassment Program, Conflict Management Program, and the Functional Review Program is on track for completion of its actions. However, as a result of recent Executive Orders that required development of action plans in FY 2010-2011 for Asian Americans and Pacific Islanders, Individuals with Disabilities, and Veterans, NASA had to add multiple actions to the Model EEO Agency Plan. The initial development of these plans, dispositioning of community group comments, and introduction of approximately 20 new actions, mid-year, did not allow time for full progress to be made. All efforts continue to progress, and are expected for completion before the end of the plan's timeframe. (See page 182 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
Implement an Agency-wide Diversity and Inclusion Framework to develop a more demographically diverse workforce and a more inclusive work environment.					5.1.1.6 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Establish a baseline for diversity by developing and implementing an Agency-wide diversity-inclusion survey.	None	None	None	10WF02 Green	AMO-11-8 Green
FY 2011 Performance Goal					FY 2011
Assure that student participants in NASA higher education projects are representative of the diversity of the Nation.					5.1.2.1 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
Achieve 40 percent participation of underserved and underrepresented (in race and/or ethnicity) in NASA higher education projects.	7ED2 Green	8ED03 Green	9ED3 Red	10ED03 Yellow	ED-11-1 Yellow
Why NASA rated APG ED-11-1 Yellow: This annual performance goal was not met. Out of the 15,947 participants in NASA higher education programs who self-reported their race and ethnicity, 35 percent, reported being a member of an underserved or underrepresented race or ethnic group. NASA's aggressive goal of 40 percent, exceeds the national averages for underserved and underrepresented participation in higher education, and was a challenge that the Agency chose to undertake. The participation in NASA's programs did meet or exceed the percentages of underrepresented minorities pursuing higher education studies in STEM fields nationwide (between 11 to 21 percent of these degrees, at the bachelor level, according to the National Science Foundation Report, Women, Minorities and Persons with Disabilities in Science and Engineering: 2011). (See page 184 for the Performance Improvement Plan.)					
Achieve 45 percent participation of women in NASA higher education projects.	None	None	None	None	ED-11-2 Yellow
Why NASA rated APG ED-11-2 Yellow: This annual performance goal was not met. Out of the 15,568 participants in NASA higher education programs who self-reported their gender, 39 percent, reported being female. Albeit a greater number of women currently pursue higher education studies in the United States, men pursue a higher proportion of the degrees in science and engineering fields. For example, compared with men, women earn degrees at medium to low levels in physical sciences and mathematics (between 30 to 44 percent of these degrees), and at low levels in computer science and engineering (between 18 to 27 percent of these degrees). Despite the statistics, NASA still chose to set an aggressive goal of 45 percent, and fell just short of the challenge. (See page 184 for the Performance Improvement Plan.)					

Outcome 5.2

Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.

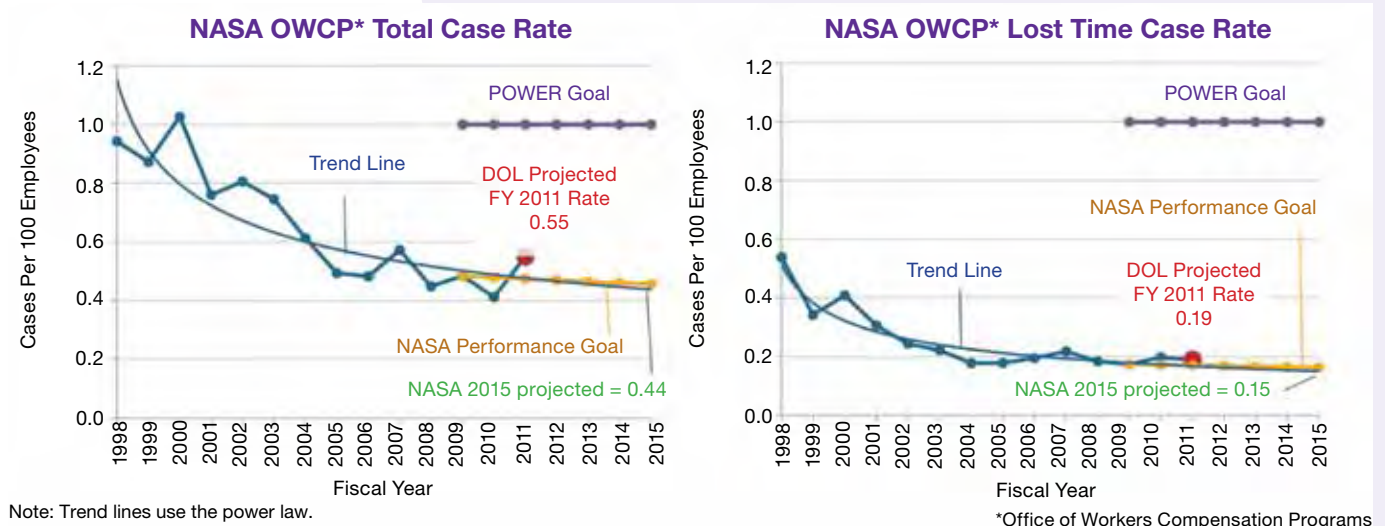
NASA's assets are critical to enable mission success. NASA plans for, operates, and sustains the infrastructure that provides the programs and projects with the facilities, capabilities, tools, and services they require. Toward this end, NASA performs periodic Agency-level integrated assessments of the supply of technical capabilities across all Centers and integrated analyses of the demand for these capabilities across all programs. This provides NASA with core information needed to balance institutional supply with program and project demand to ensure that capabilities are affordable and aligned with long-term strategic goals.

Several offices contribute to the achievement of this outcome. The Office of Safety and Mission Assurance assures the safety and enhances the success of all NASA activities through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, and quality assurance policies and procedures. The Office of the Chief Information Officer (OCIO) delivers reliable, innovative, and secure information technology (IT) services critical to all aspects of the Agency's operations. The Office of Strategic Infrastructure ensures that facilities and assets are appropriate and available to meet mission needs. This includes identifying assets and facilities that NASA no longer needs, maintaining and upgrading those in use, building or acquiring as needed, transitioning assets and facilities to new programs, and planning strategically for future needs. For FY 2011, these offices conducted the following activities.

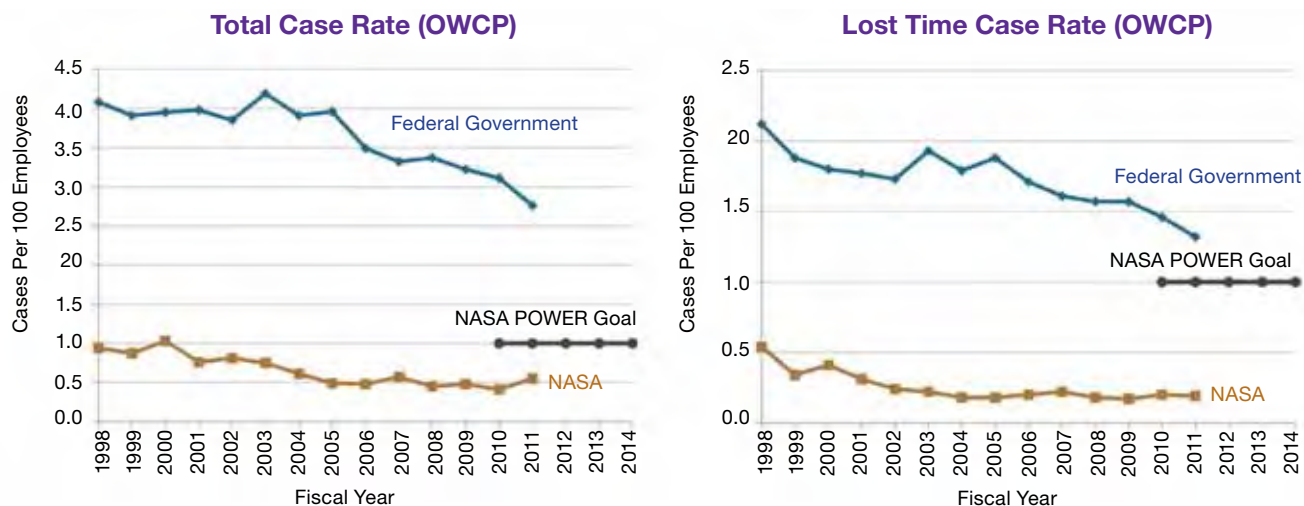
Maintaining safety, quality, risk assessment, reliability, and maintainability as integral features of all programs and operations

Success starts with safety

In addition to targeted initiatives, NASA must maintain a very high level of vigilance in its day-to-day operations to assure the continued availability of key assets and personnel. Key disciplines include the Safety and Mission Assurance program, which in 2011 continued to refine policies, procedures, and technical standards and provide programs of emphasis that will better enable NASA's programs and operations to achieve mission success via the mishap prevention efforts, as well as providing operational surveillance of hazardous operations, and independent assessments providing "checks and balances" of key programmatic decisions.



FY 2009 (NASA's baseline year), the total number of cases was 89. At the end of the third quarter, the Department of Labor (DOL) projected the total number of cases for FY 2011 would be 101, which equates to a projected end of year total case rate of 0.55 (left chart). In FY 2009, the total number of lost time cases was 32. At the end of the third quarter, DOL projected number of lost time cases for FY 2011 would be 35, which equates to a projected end of year lost time case rate of 0.19 (right chart). Both charts show that NASA is well below the goal set for the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative and projects that it will remain below the POWER goal through 2015. However, for FY 2011, NASA challenged itself to improve injury rates even further, by decreases of one percent per year, despite the POWER goal exception for agencies having a rate below one case per 100 employees. (Credit: NASA)



Source: Occupational Safety and Health Administration, "Federal Agency Safety and Health Occupational Injury and Illness Statistics."
 Note: Case rates are derived from claims submitted to the OWCP.

For the FY 2011 total case rate and lost time case rate, NASA currently is below the POWER goal, below the rate for the Federal government as a whole, and below the rate for other comparable Federal government agencies. However, NASA has challenged itself to improve injury rates even further, and decreased one percent per year, despite the POWER goal exception for agencies having a rate below one case per 100 employees. (Credit: NASA)

Providing efficient, effective, and secure IT services for NASA and for dissemination of information to the public

Given the technically advanced, complex, high-risk nature of NASA's work, information technology (IT) services are essential to Agency mission performance and mission support management. NASA's IT strategy calls for the ability to support current and future missions, both reliably and affordably, with an increasingly flexible, mobile workforce. The OCIO will continue to consolidate legacy contracts and data centers and increase the use of cloud computing. These efforts will generate cost savings through economies of scale while simultaneously improving the integration, goal alignment, security, oversight, and accountability across NASA's enterprise IT service providers. As part of OCIO's continuous enterprise improvement cycle, design and management of NASA's enterprise architecture will provide the roadmap and tools to navigate from IT strategy through execution and maintenance while enabling a consistent methodology for technology infusion and innovation.

NASA's Agency IT Services (AITS) Program provides enterprise applications that support NASA's business and information needs, with new initiatives and enhancements focused on improving business and management practices. The AITS Program also provides many common enterprise capabilities like integrated e-mail, calendaring, instant messaging, directory services, and the NASA public Web portal. The NASA IT strategy is to improve service delivery across a portfolio of enterprise IT assets by delivering integrated services that are increasingly driven by customer priorities and collaboration and scaled appropriately to achieve cost savings and delivery efficiencies.

Transitioning to an Enterprise-Based Approach for NASA IT

The IT Infrastructure Integration Program (I3P) continues to be a key pillar in the ongoing transformation of NASA's core IT services from a Center-based model to an enterprise-based service provisioning and management model. The scope of I3P is broad and includes consolidation and central management of IT services in the areas of Tier 1 service desk and IT service ordering, web services development and management, enterprise business applications development and operations, integrated network/communications services, and end user services. I3P will result in more standardized, cost effective systems and services that will increase the Agency's ability to provide efficient IT services.

In FY 2011, NASA awarded contracts for major I3P service components: NASA Integrated Communications Services (NICS), which will provide Agency corporate and mission communication needs; Agency Consolidated End-user Services (ACES), which will provide NASA staff with personal computing services, mobile communications devices, and collaboration services; and the NASA Enterprise Applications contract to operate and maintain NASA's set of integrated enterprise business systems supporting all 10 NASA Centers, NASA Headquarters, and the NASA Shared Services Center.

Leveraging IT Innovation to Make NASA More Productive

The OCIO also established a new position, the Chief Technology Officer (CTO) for IT, to work with industry and other Government organizations to identify innovative technology that can be quickly evaluated and introduced to NASA's scientists and engineers to improve their ability to conduct research and support NASA missions.

The Agency CTO identified CTOs at each Center and the Jet Propulsion Laboratory and established a set of virtual laboratories to solicit and evaluate proposals for innovative solutions to real world NASA issues. Some examples of proposals that were funded through the virtual laboratories in FY 2011 include the following:

- **Agency SharePoint 2010 My Site:** The laboratory will conduct a feasibility assessment of using 2010 My Site with SharePoint for Agency purposes. Using a working prototype, the project will test My Site's capability as a portal for user information across the Agency by aggregating various SharePoint infrastructure information, across the Agency through My Site. SharePoint is an online tool for information sharing and document collaboration using a browser interface. My Site is a personal site that gives users a central location to manage and store documents, content, links, and contacts. The prototype, if viable, has the potential to make it easier for employees to access their files offsite and to improve document sharing.
- **Collaboration Application Interoperability in the Cloud:** Cloud computing delivers computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility over a network like the Internet. This laboratory will evaluate hosted collaboration application solutions that centralize multiple Agency collaboration architecture functional requirements, initiate a repeatable process for application innovation/integration within the NASA architecture, and architect solutions for prototype development that integrate separately hosted cloud collaboration application environments.
- **Google Apps Pilot:** This collaborative laboratory will pilot Google Apps and prepare it for release as an Agency software as a service. Google works has been working with the U.S. government to create a dedicated, secure cloud computing system.
- **Paperless Conference Room Study:** The laboratory will evaluate the intuitiveness and effectiveness of using a tablet device to distribute presentations to meeting attendees on their tablets to eliminate the need for printing handouts. The goal is to investigate the feasibility of an integrated capability that allows easy configuration for presentation, intuitive ability for viewers to capture notes on the presentation and e-mail the presentation along with the notes to themselves, and the ability for the presenter to wipe the presentation and notes from the attached tablets on completion of presentation.

It is expected that through these early technology exploration activities, NASA can increase the productivity of its workforce and provide integrated information management to not only to its employees but also to the general public in a far more usable form.

Developing and implementing long-term infrastructure plans

Creating a facilities Master Plan

In the area of facilities management, NASA has undertaken a multi-pronged effort to integrate decision making across the Agency to arrive at long-term facilities solutions that preserve and provide the institutional resources needed to support NASA's mission. The first product from the implementation of the new strategy is an integrated Agency Master Plan.

The Agency-wide Master Plan conveys a comprehensive plan for facilities development and stewardship and will enable significant progress towards NASA's overall goal of a sustainable, right-sized infrastructure set aligned with mission requirements. The plan will allow NASA to leverage facility investments to manage strategic risks (e.g., deferred maintenance, the possible erosion of research capabilities through insufficient facilities and equipment, the impacts of climate change) and total cost of facilities ownership, particularly renewal and energy/operations costs. The plan includes a five- and 20-year Agency Capital Investment Program Plan and it compares benchmarks and projected progress against goals in the areas of readiness, size, and stewardship.

Reducing and recycling can make a big difference

A key aspect of the new facilities strategy is reducing operating costs and eliminating inactive and obsolete facilities that are no longer required for NASA's Mission through its demolition program. Abandoned facilities pose a potential safety and environmental liability. These abandoned facilities still must be maintained at minimal levels to prevent increasing safety and environmental hazards, imposing a drain on limited maintenance dollars. Demolishing these abandoned facilities allows the Agency to avoid non-productive operating costs required to keep abandoned facilities safe and secure and reduce the liability associated with these facilities. During 2011, NASA initiated the facilities demolition process for five significant Agency facilities.

Demolishing for the future while remembering the past

At Langley Research Center, two facilities—the 16 Foot Transonic and the Langley Full Scale Tunnels—are being taken down, piece by piece. They are victims of age and studies that say they are no longer needed for a number of reasons. Their demolition is part of Langley's ongoing repair-by-replacement strategy (called New Town) and revitalization to make the Center more efficient and better prepared for the future.

While the facilities may no longer be needed, they are leaving behind a notable history. The Langley Full Scale Tunnel, with its two propeller assemblies bigger than a three-story building and test section 30 feet wide by 60 feet long, was known worldwide for having hosted Orville Wright, Charles Lindbergh, and Howard Hughes, as well as testing hundreds of aircraft and spacecraft since it started operation in 1931.

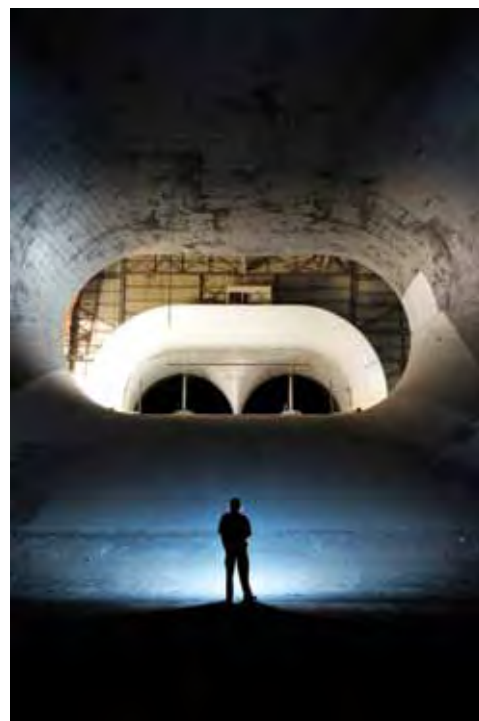
Ultimately four tunnels are slated to come down as part of a NASA-wide effort to remove excess capability and reduce deferred maintenance costs. After the Langley Full Scale Tunnel work is finished, two smaller tunnels at Langley will come down: the 8-Foot Transonic Pressure Tunnel, which was closed in 1996, and the 8-Foot High Speed Tunnel, an historic landmark that was deactivated in 1956.

The tunnels are part of a \$5.7 million demolition contract, but the actual cost of the project to the government will be \$3.6 million, according to the Center Operations Directorate, because more than two million dollars worth of the materials, including steel and concrete, will be recycled.

Langley officials have worked hard to make sure all the tunnels' achievements have been properly documented in print and imagery and artifacts preserved in displays and museums. Some of the blades from the 16-Foot Tunnel have been incorporated into the first New Town building at Langley and parts of the other tunnels are slated to go to museums, including the Smithsonian Institution.

Saving water across NASA

For 2011, NASA reported a potable water use intensity reduction of 9.8 percent from the Agency's baseline, exceeding the target of eight percent. NASA's Ames Research Center was recognized for implementing a water reuse project, winning the Federal Energy and Water Management's Water Conservation Small Group Award. Ames partnered with the City of Sunnyvale to reduce consumption of potable water and to use reclaimed water for landscape irrigation, construction site dust control, and washing aircraft. The Native Plant Initiative converts high maintenance, water-intensive turf/grass areas to low-maintenance, drought-tolerant native plants. The overall effort decreased Ames' potable water consumption by more than 80 million gallons and saved \$400,000 annually. In addition to the Ames project, water conservation activities and projects were also implemented at Langley Research Center, Michoud Assembly Facility, and Stennis Space Center, resulting in an estimated total of \$300,000 in annual savings and 127 million gallons in annual water savings.



A member of the demolition crew stands in silhouette inside Langley's Full-Scale Tunnel. (Credit: NASA/S. Gibbs, G. Homich, S. Smith)

Outcome 5.2					
Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.					
FY 2011 Performance Goal					FY 2011
Through 2015, assure zero fatalities or permanent disabling injuries to the public.					5.2.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during the fiscal year.	None	None	None	10SMS01 Green	AMO-11-9 Green
FY 2011 Performance Goal					FY 2011
By 2015, achieve a four percent reduction in the total case rate and lost time rate for the NASA civil service work force.					5.2.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Reduce Total Case Rate and Lost Time Case Rate by one percent, in accordance with the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative.	None	None	None	None	AMO-11-10 Red
Why NASA rated APG AMO-11-10 Red: At year-end, NASA was about 2 times lower (better) than the President's Protecting our Workers & Ensuring Reemployment (POWER) goal for TCR and 5 times lower (better) than the POWER goal for LTCR. However, NASA undertook a stretch goal of lowering the Agency's already low rates by 1 percent, from the POWER baseline goal year (FY 2009). The data for this calculation is current through the third quarter (fourth quarter data is not available until December), with end-of-year projections by the Department of Labor's Office of Workers' Compensation Programs, who must validate and accept these cases, that place NASA at small upswings in both TCR and LTCR from the FY 2009 base year (thus missing the 1 percent internal goal). Even with the slight upswings, NASA still remains one of the best in the government, and still significantly below (better than) the POWER goals. (See page 161 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
By 2015, reduce damage to NASA assets by eight percent from the 2010 baseline.					5.2.1.3 Red
Why NASA rated Performance Goal 5.2.1.3 Red: NASA does not anticipate meeting this performance goal by 2015, due to the Glory launch vehicle mishap in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, irrespective of no damage beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals, that also feed this performance goal. (See page 161 for the Performance Improvement Plan.)					
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Reduce damage to NASA assets by two percent per fiscal year, based on a five-year running average.	None	None	None	10SMS03 Green	AMO-11-11 Red
Why NASA rated APG AMO-11-11 Red: This annual performance goal will not be met in FY 2011, due to the loss of the Glory mission. Based on the magnitude of the cost of the loss of the Glory mission, FY 2011 will see a growth from FY 2010, rather than a reduction.					
FY 2011 Performance Goal					FY 2011
By 2014, consolidate and centralize the management of information technology (IT) enterprise services for end user services, communications, enterprise applications, enterprise data centers and web services.					5.2.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Achieve Initial Operating Capability (IOC) for five Service Offices (Web Services, Communications, Enterprise Service Desk, End User Services, and NASA Enterprise Applications) as part of the NASA Information Technology Infrastructure Integration Program (I3P).	None	None	None	10IT02 Green	AMO-11-12 Yellow
Why NASA rated APG AMO-11-12 Yellow: Four of the five planned service offices achieved Initial Operating Capability (IOC). The End User Services (ACES), Enterprise Applications (EAST), Enterprise Service Desk (ESD), and Communications (NICS-Networking) services all have their office structures in place, are managing the transition to these new services, and continue to operate the current services. The one service office that did not reach IOC in FY 2011 is the one for the Web services (WEST). The implementation of this initiative has been delayed to resolve some issues with the contract award. NASA remains on track for the consolidation and centralization of these services and capabilities by 2014. (See page 174 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
By 2015, implement a capability to identify and prevent unauthorized intrusions on the NASA institutional and mission networks.					5.2.2.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Implement intrusion detection sensors monitored by the NASA Security Operations Center (SOC) on 75 percent of NASA institutional network monitoring sites.	None	None	None	10IT06 Red	AMO-11-13 Green
FY 2011 Performance Goal					FY 2011
By 2014, decommission the Agency Administrative mainframe computer.					5.2.2.3 Green

FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Implement, in the SAP environment, the replacement for the mainframe-based NASA Supply Management System.	None	None	None	None	AMO-11-14 Green
FY 2011 Performance Goal					
By 2015, reduce data center energy consumption by 30 percent.					5.2.2.4 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop a data center consolidation plan for NASA that includes an enterprise assessment of NASA's data center footprint.	None	None	None	None	AMO-11-15 Green
FY 2011 Performance Goal					
By 2015, establish at least four innovation laboratories that provide more effective, efficient, and responsive information technology (IT) across NASA in support of the Agency's Mission.					5.2.2.5 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Implement a Core Information Technology (IT) Innovation Laboratory infrastructure to support experimental technology incubation activities in areas ranging from communications, information dissemination, and collaboration application interoperability in a cloud environment.	None	None	None	None	AMO-11-16 Green
FY 2011 Performance Goal					
Consolidate functions and offices to reduce real property need, and use Agency Integrated Master Plan to identify and dispose of excess and aged facilities beyond useful life.					5.2.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Finalize 8 of 10 Center Master Plans and incorporate into the Agency Integrated Master Plan.	None	None	None	10FAC01 Green	AMO-11-17 Green
Initiate facilities demolition process for five significant Agency facilities.	None	None	None	None	COF-11-1 Green
FY 2011 Performance Goal					
HPPG: Conserve valuable natural resources by reducing NASA's energy and water use.					5.2.3.2 Yellow
Why NASA rated Performance Goal 5.2.3.2 Yellow: Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA expects to exceed its targets on the measures related to water use and fleet management, but fall short on the energy intensity goals. See rating explanation for ECR-11-1 for more detailed information on the energy intensity measure. (See page 159 for the Performance Improvement Plan.)					
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Reduce energy intensity use annually by three percent from an FY 2003 baseline.	None	None	None	10FAC04 Red	ECR-11-1 Red
Why NASA rated APG ECR-11-1 Red: Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA reduced energy intensity by an estimated 1 percent, for an 8 percent reduction from 2003 baseline. The FY 2011 goal was 18 percent from the 2003 baseline and NASA expects to reduce energy intensity by 10 percent (+/- 2 percent) in that same timeframe. Recent NASA topline budget reductions lowered funding planned for specific energy efficiency measures and new building construction, restoration, and rehabilitation, negatively impacting NASA's energy conservation program and reducing chances of meeting Federal requirements. Despite the reduced funding, NASA continues to work to reduce energy intensity, and during FY 2010-FY 2011, the Agency completed construction and received LEED certification for 12 new buildings (1 Certified, 2 Silver, 6 Gold, and 3 Platinum). Three completed buildings are under review for certification (2 Silver and 1 Gold), and ten more buildings are under construction seeking LEED certification of Silver or Gold level in FY 2012. Eleven buildings are in the design phase for Silver or Gold LEED level. (See page 159 for the Performance Improvement Plan.)					
Reduce potable water use annually by two percent from an FY 2007 baseline.	None	None	None	10FAC06 Green	ECR-11-2 Green
Reduce fleet vehicle energy use annually by two percent of petroleum products from an FY 2005 baseline.	None	None	None	10FAC05 Green	ECR-11-3 Green
Uniform and Efficiency Measures					
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Maintain system execution time during the year-end close process at FY 2010 baseline.	None	8IEM07 Red	9IEM9 Red	10IT12 Green	AMO-11-23 Green

Outcome 5.3

Ensure the availability to the Nation of NASA-owned strategically important test capabilities.

NASA is responsible for stewardship of space and aeronautical laboratory systems, facilities, core competencies, and engineering and research capabilities. The Rocket Propulsion Test (RPT) Program within the Human Exploration and Operations (HEO) Mission Directorate, the Aeronautics Test Program (ATP) within the Aeronautics Research Mission Directorate, and the Strategic Capabilities Assets Program (SCAP) within the Office of Strategic Infrastructure ensure that these assets and capabilities are available to serve current and future needs of the Agency and the Nation. Assets and facilities managed and maintained by these programs—many of which are unique within the United States—are available to other government agencies and the commercial sector for developing and testing their technologies.

RPT optimizes use of NASA's rocket propulsion test assets for efficiency and cost effectiveness and ensures that a minimum core capability for all aspects of rocket propulsion testing is maintained. These capabilities are critical to ensuring the Nation's access to space by: providing engine, component, systems and anomaly testing; encouraging the pursuit of partnerships with the emerging commercial space sector; supporting Agency programs relative to the utilization of RPT resources; and investing in test technology and maintenance strategies.

ATP corporately manages and ensures the strategic availability of a minimum, critical suite of aeronautical test facilities (like wind tunnels), support aircraft, laboratories, and the western aeronautical test range, necessary to meet the long-term aeronautical test requirements for the Nation.

SCAP identifies, prioritizes, and manages Agency key assets and capabilities that are essential to the future needs of NASA and/or the Nation, including some capabilities that lack an adequate business base. This function ensures that key assets and capabilities, as elements of the Agency's physical and intellectual infrastructure, are available to perform the Agency's Mission. They perform an Agency cross-cutting function that encompasses assets and capabilities that may be used across multiple mission directorates and program areas.



Maryland Senator Barbara Mikulski and NASA Administrator Charles Bolden cut the ribbon at the new Horizontal Integration Facility (HIF) at NASA's Wallops Flight Facility, Wallops Island, Virginia. The HIF will support medium-class mission capabilities. The first customer to use the facility will be Orbital Sciences Corporation with its Taurus II launch vehicle. Wallops is managed by the Goddard Space Flight Center in Maryland. (Credit: NASA)

Meeting NASA, Department of Defense, and commercial rocket propulsion testing capabilities and requirements

Maintaining the Nation's access to space requires continuous investment in development, evolution, and maturation of propulsion technologies, as well as qualification testing of flight propulsion systems. RPT optimizes use of NASA's rocket propulsion test assets for efficiency and cost effectiveness and to ensure a minimum core capability for all aspects of rocket propulsion testing is maintained. RPT provides engine, component, systems, and anomaly testing, encourages the pursuit of partnerships with the emerging commercial space sector, supports Agency programs relative to the utilization of RPT resources, and invests in test technology and maintenance strategies.

Providing aeronautics test facilities to meet the needs of NASA and national aerospace programs

The Aeronautics Test Program (ATP) is designed to corporately manage and ensure the strategic availability of a minimum critical suite of aeronautical test facilities which are necessary in meeting the long-term aeronautical test requirements for the Nation. ATP is comprised of two projects to support the goals noted:

The J2-X engine 10001 being developed for NASA's Space Launch System recently completed its sixth test firing on September 28, 2011, at the [Stennis Space Center A-2 test stand](#). NASA met all its FY 2011 goals, including the 40 second run time at a power level of 99 percent. Until 2009, RPT used the A-2 test stand to test Space Shuttle engines. After a decommissioning period, Stennis employees spent 10 months converting the stand to the parameters needed to test engines for NASA's new engine series. NASA conducted a facility readiness review on the A-2 test stand in mid-March and found that all the major modifications were complete and the test stand was ready to begin testing the J-2X engine. (Credit: NASA)



- The Aeronautics ground test facilities consist of various categories of wind tunnels located at [Ames Research Center](#), [Glenn Research Center](#), and [Langley Research Center](#).
- The flight operations and test infrastructure are located at the [Dryden Flight Research Center](#) and include the western aeronautical test range, support aircraft, testbed aircraft, simulation and flight landing loads laboratories.

ATP upgrades wind tunnels

Strategic initiatives accomplished by ATP in FY 2011 include investments and upgrades at five major wind tunnels across its portfolio to provide new capability and improved facility reliability and investments in flight assets to enable a new flight research capability. Included in ATP investments are a new acoustic measurement capability at the 14 x 22 Foot tunnel at Langley Research Center, a new engine icing test capability at the Propulsion Systems Laboratory at Glenn Research Center, and a modified research aircraft to enable [Aeronautics Research Mission Directorate](#) flight testing at the Dryden Flight Research Center. ATP investments also led to development and implementation of new and improved test technologies to increase productivity and efficiency and improve research data quality, including investments in the National Force Measurement Technology Capability.

Good decisions start with the right tool

Also in FY 2011, ATP finalized a Capability Reliance Framework, a top-level decision analysis instrument that provides a view of the entire suite of ATP ground test capabilities and includes similar test assets owned and operated by the [Department of Defense](#). This decision analysis tool will inform decision makers about capability needs, which facilities and resources operated by NASA and other entities could serve those needs, reliance opportunities, condition and lifecycle costs, and other related issues.

Outcome 5.3					
Ensure the availability to the Nation of NASA-owned, strategically important test capabilities.					
FY 2011 Performance Goal					FY 2011
Develop and execute the Rocket Propulsion Test (RPT) Master Plan.					5.3.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Release the Rocket Propulsion Test (RPT) Master Plan.	None	None	9SFS4 Yellow	10SFS09 Yellow	SFS-11-1 Green
FY 2011 Performance Goal					FY 2011
Ensure that testing capabilities are available in order to support the research, development, test and engineering milestones of NASA and Department of Defense (DoD) programs.					5.3.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Achieve ratings greater than 86 percent for overall quality and timeliness of Aeronautics Test Program (ATP) facility operations.	None	None	None	10AT11 Green	AR-11-11 Green

Outcome 5.4

Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.

Both human and robotic space exploration require an efficient and reliable infrastructure of assets, facilities, and services to keep operations running smoothly. These include access to launch vehicles, launch and range complexes, and a communication network to receive and transmit data.

The Launch Services Program (LSP) is responsible for understanding the full range of civil space launch needs. They work closely with other government agencies and the launch industry to make available the safest, most reliable, on-time, and cost-effective commercial launch opportunities over a wide range of launch systems. LSP personnel work with customers from universities, industry, government agencies, and international organizations from the earliest phase of mission planning to purchase of fixed-price launch services from domestic suppliers. LSP personnel also seek opportunities to share unused payload capacity aboard non-NASA launches to leverage launch funds. Most importantly, they provide oversight to help NASA's valuable, one-of-a-kind missions achieve their space flight objectives.

The Human Exploration and Operations (HEO) Mission Directorate and the Kennedy Space Center have been working to prepare the Center for future government and commercial space exploration by transitioning, refurbishing, and upgrading facilities. This includes launch pads and the launch control center.

Space Communications and Navigation (SCaN) coordinates multiple space communications networks, as well as network support functions to regulate, maintain, and expand NASA's space communications and navigation capabilities in support of all NASA's space missions. These networks include satellites that relay data from mission spacecraft to the ground and ground assets and facilities. SCaN reviews national and international data standards with the aim to keep systems compatible and reviews the Agency's technology needs to keep the systems efficient, reliable, and cost-effective. They also are developing a communication and navigation architecture to serve NASA's needs through 2030.

SCaN completed some key milestones for its development projects during FY 2011.

- The Space Network Ground Segment Sustainment project completed its System Requirements Review (SRR). The goal of the project is to implement a flexible and extensible ground segment that will allow the Space Network to maintain the high level of service in the future and accommodate new users and capabilities, while reducing the effort required to operate and maintain the system. The SRR examines the functional and performance requirements defined for the system and the preliminary project plan and ensures that the requirements and the selected concept will satisfy the needs of the Space Network.
- The Tracking and Data Relay Satellite (TDRS) project completed System Integration Review (SIR) for the TDRS K satellite, which will become part of the space segment of the Space Network. The SIR evaluates the readiness of the project to start flight system assembly, test, and launch operations.

Ensuring reliable and cost-effective access to space

Successes tempered by a loss

The Launch Services Program (LSP) managed the launches of four NASA missions in FY 2011. LSP launched NASA's Aquarius instrument aboard the Space Agency of Argentina (Comisión Nacional de Actividades Espaciales) SAC-D spacecraft into low Earth orbit on June 10, and sent Juno toward Jupiter on August 5. The Gravity Recovery and Interior Laboratory (GRAIL) mission, designed to increase knowledge of Earth's Moon, launched on September 10. Unfortunately, the March 9 launch of the Glory mission was unsuccessful and the spacecraft was lost. Upon completion of the Mishap Investigation Board, NASA will develop and execute a corrective action plan.

Working to expand the selection of launch vehicle providers

Working across the launch vehicle industry, LSP is supporting the emergence of a U.S. commercial space sector by providing competitive opportunities to U.S. commercial launch providers. In FY 2011, LSP executed a procurement that allows new providers to be added and existing providers to "on-ramp" additional launch vehicles to an existing contract.

NASA, NRO, USAF establish strategy for certifying new expendable launch vehicles

Just after the end of the fiscal year, NASA, the U.S. Air Force, and the National Reconnaissance Office (NRO) signed an agreement to establish clear criteria for certification of commercial providers of launch vehicles used for national security space and civil space missions.

The U.S. government is committed to procuring commercial launch services for its satellite and robotic missions, including evolved expendable launch vehicle (EELV) launches. The new entrant launch vehicle certification strategy is the latest step in a cooperative effort by the three agencies to take advantage of new launch capability for their missions.

The agencies previously signed a Letter of Intent in October 2010, signaling their collaboration on launch requirements. They signed a Memorandum of Understanding in March, outlining their plans for future EELV-class launch vehicle acquisition, including the need for a coordinated strategy for certification of new entrant launch systems.

The basis of the new strategy comes from NASA's existing policy directive for launch vehicle risk mitigation. It also recognizes that mission-unique requirements from each of the three agencies may result in different certification approaches to mitigate launch risk. The document provides a common framework and language among the agencies for communicating expectations to new launch service providers.

The risk-based certification framework allows the agencies to consider both the cost and risk tolerance of the payload and their confidence in the launch vehicle. For payloads with higher risk tolerance, the agencies may consider use of launch vehicles with a higher risk category rating and provide an opportunity for new commercial providers to gain experience launching government payloads.

Within a given risk category rating, if new entrants have launch vehicles with a demonstrated successful flight history, then the government may require less technical evaluation for non-recurring certification of the new launch system. This new strategy further enables competition from emerging, commercially developed launch capabilities for future Air Force, NASA, and NRO missions.

Building the Florida launch and range complex of the future

Launch equipment test facility is ready for new business

Kennedy Space Center's Launch Equipment Test Facility, or LETF, is an engineer's paradise, featuring fixtures capable of simulating launch conditions, a machine shop and a welding facility, and a new vehicle motion simulator, which simulates all of the movements a vehicle could experience from rollout to launch.

Since 1977, LETF has supported NASA's Launch Services, Space Shuttle, International Space Station, and exploration programs, as well as commercial providers. NASA recently completed a four-year, \$35 million comprehensive upgrade to make sure the testing ground remains at the top of the support system testing pyramid.



Workers learn about the LETF's capabilities in its 6,000-square-foot high bay. (Credit: NASA/D. Gerondidakis)

Launch Pad 39B retooled for future

Launch Pad 39B at NASA's Kennedy Space Center in Florida recently made way for a new generation of rockets when workers took down the gantry that stood in support of Space Shuttles for 30 years. Whatever rocket heads out to the pad in the future, it's going to bring its support structure with it. With that in mind, the future Pad B will provide all the fluids, electrical, and communications services to the launch platform.

NASA plans to use the Mobile Launcher, or ML, to carry the new Space Launch System rocket to the pad and possibly use one of the Mobile Launcher Platforms, or MLP, for commercial vehicles. Construction will start soon to build two electric elevators, sized to reach all levels of the ML and MLP, at the pad to replace the aged one there now.



The flame trench at Launch Pad 39B, which is currently lined with fireproof bricks and concrete, will be refurbished and the flame deflector in the middle could become portable to handle future rockets of different sizes. NASA used a moveable flame trench during Apollo. (Credit: NASA/J. Grossmann)

Along with the dramatic changes on top of the pad that removed the Shuttle structures, there is a considerable amount of refurbishment under way inside the launch pad perimeter. NASA already has removed a million feet of cables, the storage tanks for hypergolic fuels, and the corrosive chemicals that powered the Shuttle's thrusters in space. Instrumentation that monitors and controls the facility and ground systems, as well as the communications systems, has been replaced with new state-of-the-art equipment. NASA also has installed a new weather instrumentation system at the pad that monitors meteorological conditions and detects lightning.

NASA is fixing and sealing chipped and damaged concrete pedestals supporting propellant lines running from storage tanks to the pad's surface so they can handle at least 25 more years beside the ocean. The huge white spheres that held liquid hydrogen and liquid oxygen have been emptied, too. They will be repainted, but not taken down. The old liquid oxygen water-cooled vaporizer will be replaced with modern, air-cooled one that is far more efficient than the water-cooled system used the past 30 years.

Expanding and improving communications and navigation services for current and future missions

In FY 2011, SCA_N maintained at least 99 percent proficiency of all of its networks, providing communication and navigation services to 29 spacecraft using the Deep Space Network, 35 spacecraft using the Space Network, and 33 spacecraft using the Near Earth Network. The Near Earth Network also provided communication and navigation services to 33 launches during launch and early orbit phases.

The Deep Space Network is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The network also supports selected Earth-orbiting missions. The Space Network consists of a space segment, composed of the Tracking and Data Relay Satellite System, and a ground segment, which includes the White Sands Complex and the Guam Remote Ground Terminal. Data from the satellites is downlinked to the ground segment. The Near Earth Network provides tracking, telemetry, and communications services, using antenna assets located around the world, for orbital missions and occasionally suborbital missions.

SCA_N continued the sustaining and engineering of its aging networks, including completion of upgrades to the Near Earth Network assets at McMurdo Ground Station in Antarctica. The Deep Space Network Aperture Enhancement project broke ground for adding 34-meter (110.5 foot) antennas at the Canberra Deep Space Communications Complex in Canberra, Australia. The program also made significant progress in technology development. The Communication, Navigation and Networking re-Configurable Testbed (CoNNeCT) made significant progress and was readied for System Acceptance Review in early FY 2012.

Outcome 5.4					
Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.					
FY 2011 Performance Goal					FY 2011
Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.					5.4.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Sustain 100 percent success rate with the successful launch of NASA-managed expendable launches as identified on the Launch Services Flight Planning Board manifest.	None	None	None	10SFS11 Green	SFS-11-2 Yellow
Why NASA rated APG SFS-11-2 Yellow: This annual performance goal was not met due to the loss of the Glory mission. NASA's Glory satellite did not reach orbit after its liftoff on March 4, 2011, due to a launch vehicle mishap. The Launch Services Program successfully launched the other three missions scheduled for this fiscal year. Aquarius successfully launched aboard a Delta II launch vehicle on June 10, 2011 from Vandenberg Air Force Base, CA. The Juno mission launched aboard an Atlas V rocket on August 5, 2011, from Cape Canaveral Air Force Station, FL. And lastly, the GRAIL mission launched aboard a Delta II Heavy launch vehicle on September 10, 2011. (See page 163 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
Continue utilizing existing contract mechanisms and agreements with emerging launch vehicle providers to gain information for future Launch Service orders and to provide technical exchanges to enhance early launch success.					5.4.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop processes for space transportation partner information sharing between NASA's Launch Services Program (LSP), Exploration Systems Mission Directorate (ESMD), ISS, and other government customers, including but not limited to Department of Defense (DoD).	None	None	None	10SFS10 Green	SFS-11-3 Green
FY 2011 Performance Goal					FY 2011
By FY 2014, enable future government and commercial launching and testing from the Florida launch and range complex.					5.4.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Develop a 21st Century Space Launch Complex (21st CSLC) plan.	None	None	None	None	SFS-11-4 Yellow
Why NASA rated APG SFS-11-4 Yellow: This annual performance goal was not met due to a revision on the originally planned schedule for this activity. As is typical with NASA programs and projects in the formulation phase, schedules are expected to change as they are refined heading toward the development phase. As the fiscal year progressed, the maturity of the Human Exploration Capabilities programs increased, and NASA began to work through the significant milestones and associated product development and has settled on the current schedule. Under this schedule, NASA expects that this activity will be completed in the first quarter of FY 2012. (See page 169 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
By 2014, launch two functionally identical Tracking and Data Relay Satellite (TDRS) spacecraft in geosynchronous orbits to replenish the Tracking and Data Relay Satellite System (TDRSS) constellation.					5.4.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete Tracking and Data Relay Satellite (TDRS) K Payload and Bus Integration and test.	None	None	9SFS6 Green	10SFS07 Yellow	SFS-11-5 Green
FY 2011 Performance Goal					FY 2011
By FY 2016, replace or upgrade obsolete and unsustainable systems of the TDRSS Ground Segment at the White Sands Complex (WSC).					5.4.3.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the Space Network Ground Support Sustainment (SGSS) Integrated Baseline Review (IBR) and Systems Requirements Review (SRR).	None	None	None	10SFS08 Yellow	SFS-11-6 Green
FY 2011 Performance Goal					FY 2011
By FY 2018, replace aging and obsolete Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC).					5.4.3.3 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete Deep Space Station-35 (DSS-35) Pedestal Excavation at Canberra Deep Space Communications Complex (CDSCC).	None	None	None	None	SFS-11-7 Green

Outcome 5.5

Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success.

Strategic partnerships with the U.S. government and academic, industrial, and international organizations help NASA leverage resources, increase the impact of activities, and execute missions more effectively and efficiently. NASA works cooperatively with these partners to identify common goals, develop new technologies and applications, and share technical expertise to minimize risk. The Office of International and Interagency Relations (OIIR) provides executive leadership and coordination for all international partnerships. OIIR serves as the principal Agency liaison with the National Security Council, the Office of Science and Technology Policy, the Department of State, and the Department of Defense. OIIR also directs NASA's international relations, negotiates cooperative and reimbursable agreements with foreign space partners, provides management oversight and staff support of NASA's advisory committees, commissions, and panels, and manages the NASA Export Control Program and foreign travel by NASA employees.

To achieve this outcome, NASA is using mechanisms like building public-private partnerships, hosting government capabilities on commercial spacecraft, and purchasing scientific or operational data products from commercial satellites. The ability to procure technology or services competitively when needed, rather than maintain a capability that may not be fully used, allows NASA to focus resources for institutional and program capabilities in areas of evolving strategic importance.

Using the ISS as a National Laboratory for research, technology development, and education

NASA awards CASIS management of ISS National Laboratory Research

NASA issued a Cooperative Agreement Notice on February 14, 2011, to seek a management partner for the portion of the International Space Station (ISS) that was designated a National Laboratory in 2005. The NASA Authorization Act of 2010, which extended ISS operations until at least 2020, also directed the Agency to establish this organization.

On August 31, NASA finalized a Cooperative Agreement with the Center for the Advancement of Science in Space (CASIS) to manage the portion of the International Space Station that operates as a U.S. National Laboratory. The ISS Program will continue its focus on maintaining the ISS, coordinating available crewmember time, and delivering critical services like power and data relay that researchers need to conduct their experiments.

CASIS, the independent, nonprofit research management organization, will be located at the Kennedy Space Center, and will help ensure the ISS' unique capabilities are available to the broadest possible cross-section of U.S. scientific, technological and industrial communities.

CASIS will develop and manage a diversified research and development portfolio based on U.S. national needs for basic and applied research; establish a marketplace to facilitate matching research pathways with qualified funding sources; and stimulate interest in using the National Laboratory for research and technology demonstrations and as a platform for science, technology, engineering, and mathematics education. The goal is to support, promote, and accelerate innovations and new discoveries in science, engineering, and technology that will improve life on Earth.

Leveraging international and interagency partnerships

OIIR keeps NASA well-connected

NASA has continued to establish international and interagency partnerships to both inform and encourage broad support for NASA's planned mission activities.

NASA continued the management of 520 active international agreements with over 125 countries, which included the establishment of 106 new international agreements or extensions this year. In addition, the Agency continued the management of over 200 interagency agreements including the establishment of 40 new interagency agreements this year. NASA is directing ongoing efforts to improve coordination of the more than 800 active interagency agreements that currently exist Agency-wide. On September 22, the International Space Exploration Coordination Group (ISECG) released

the Global Exploration Roadmap (GER). This document was developed with inputs from all of the participating agencies. The GER reflects an international effort to define feasible and sustainable exploration pathways to a variety of destinations. This first iteration of the GER is intended to inform and help focus the planning currently underway in each of the partner agencies in the areas of planetary robotic exploration, advanced technology development and use of the ISS in preparation for exploration. The GER has been posted to the ISECG Web site (<https://www.globalspaceexploration.org/home>) and the NASA Web site (<http://www.nasa.gov/exploration/about/isecg/>).

Outcome 5.5					
Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success.					
FY 2011 Performance Goal					FY 2011
HPPG: Establish an independent non-profit organization (NPO) to enhance the utilization of the ISS as a National Laboratory.					5.5.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Transition management of the ISS U.S. National Lab for non-NASA research to the non-profit organization (NPO).	None	None	None	None	ISS-11-6 Green
FY 2011 Performance Goal					FY 2011
Actively engage and provide leadership in international and interagency forums.					5.5.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Complete the International Space Exploration Coordination Group (ISECG) roadmap to identify common interests among international space agencies in human and robotic exploration of the solar system.	None	None	None	None	AMO-11-18 Green

Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation and contribute to a strong national economy.

NASA's priority is to make information from missions, research, and discoveries available for the benefit of the Nation. In its [2011 Strategic Plan](#), NASA emphasized this priority by creating a new strategic goal dedicated to education, public outreach, and transparency. The Agency has two organizations focused on achieving this strategic goal.

The [Office of Education](#) (Education) stimulates student interest and achievement in science, technology, engineering, and mathematics (STEM) fields through the excitement of NASA's missions and activities. STEM-focused teachers combine their skills with NASA education products to motivate student achievement and spur creative and critical thinking both in and out of the classroom. These students will become the Nation's future STEM workforce, tackling technical and scientific challenges to improve quality of life.

The [Office of Communications](#) (Communications) shares NASA's message and information with a broad audience and encourages active participation. Traditional means like print, television, and live events continue to be a mainstay of connecting with the public. However, Communications also has adopted emerging technologies and media that allow greater access and participation by the public, students, and teachers, including virtual events, live streaming video, online chats, and social media.

Benefits

NASA Education offers structured programs for students and educators to engage in STEM learning activities. These include competing in technical design challenges, launching student-built payloads, and participating in research and hands-on engineering experiences. Some students get the opportunity to work with real-world research platforms like high-altitude balloons, sounding rockets, aircraft, and space satellites. Undergraduate and graduate students can contribute directly to NASA's missions by working with scientists and engineers on their research and technology development programs while gaining valuable experience. Workshops, courses, and grant awards help teachers use NASA themes and materials to inspire their students in STEM topics.

NASA is actively planning for the workforce of tomorrow. Education coordinates with NASA's [Offices of Human Capital Management](#) and [Diversity and Equal Opportunity](#) to ensure that NASA's portfolio of education investments align with the long-term needs of the Agency. This includes supporting internships and fellowships at the Centers to inspire students at all levels to pursue STEM-related careers vital to NASA's and the Nation's future.



On August 17, 2011, the crew of [STS-135](#), NASA's final Space Shuttle mission, and Sesame Street's Elmo welcomed visitors to "What's Your Favorite Space?" in New York City. For the free public event, co-presenters NASA and Eventi transformed an outdoor plaza into a miniature space outpost filled with displays, including an inflatable Mars rover, demonstrations, interactive exhibits, video segments, children's activities, and more. Pictured with Elmo is STS-135 Commander Chris Ferguson. (Credit: NASA/S. Smith)

Communications delivers beneficial services that span public outreach and relations, messaging, and history. These services keep the public aware of the Agency's latest activities and achievements. A public that is knowledgeable and interested in science, aeronautics, and exploration will value the impact of advances in these fields that help maintain global competitiveness and a robust economy.

The Agency's online presence also has become an essential tool for fostering transparency in operations and management practices. NASA strives to increase the amount of information—and speed at which it is available—to provide insight into the Agency's performance and stewardship of taxpayer dollars.

Risks to Achieving Strategic Goal 6

Attracting and Retaining Students in STEM. With the myriad of opportunities that compete for students' attention, NASA's challenge is to ignite a passion for science, technology, engineering and math. Part of this challenge is in reaching students, and the people who most influence them, with products and services that will attract learners at all levels to STEM careers. NASA Education uses the exciting content and results from NASA missions to develop products and services that support students, educators, and national STEM initiatives. Through these resources, NASA Education fosters development of public–private partnerships—collaborations that build communities to support STEM education and provide stability through times of economic decline. NASA Education works cooperatively with universities, professional education societies, national and state-based organizations, and school districts to ensure that NASA products and services continue to meet the evolving needs of formal and informal educators and students, both in and out of the classroom. Education seeks opportunities for early adoption of tools and techniques shown by research to positively impact teaching, learning, and interest in STEM topics.

Reaching New Audiences. There are more channels for communication and public engagement than ever before. Understanding the character of newer generations and their preferred communication modes, styles, and technologies will help NASA communicate its value. As an organization known for research and technology, NASA embraces new tools and works to keep pace with new technology. The Office of Communications must balance use of new and traditional media tools as the Agency strives to communicate across all sections of the public.

During FY 2011, NASA Education completed a key milestone for Strategic Goal 6:

- The 12 member Education Design Team completed the NASA Education Recommendation Report, an evaluation of NASA's education program in the context of current education trends requested by Administrator Charles Bolden and Deputy Administrator Lori Garver. Based on the Education Design Team's recommendations, Education will create a tightly focused portfolio of projects that fit within its Education Framework. ([Read the complete report.](#))

Outcome 6.1

Improve retention of students in STEM disciplines by providing opportunities and activities along the education pipeline.

A critical part of NASA's Mission is to inspire the next generation of explorers so that the Nation's preeminence in space exploration, aeronautics, and science can continue into the future. NASA educational tools are designed to capture student interest, nurture their natural curiosities, and excite their minds. By providing hands-on opportunities to students of all ages and their educators, and engaging them in simulations and authentic research, NASA stimulates creativity and encourages the growth of a new generation of scientists and engineers.

Many of NASA's grant recipients are university and college science, technology, engineering, and mathematics (STEM) programs. NASA [Education](#) and [Office of Diversity and Equal Opportunity \(ODEO\)](#) partner to realize the goals of equal opportunity requirements among STEM and related programs receiving NASA financial assistance, including grants for education and training. Under laws prohibiting discrimination in federally funded programs, like [Title VI of the Civil Rights Act of 1964](#) and [Title IX of the Education Amendments Act of 1972](#), ODEO conducts compliance and enforcement activities to ensure that these programs afford equal opportunities to their beneficiaries, regardless of race, color, national origin, gender, age, or disability, and that the programs are free of discrimination and harassment. NASA Education and ODEO also review the equal opportunity technical assistance given to STEM programs. Equal opportunity technical assistance provides recipient programs more effective tools for conducting and measuring the success of targeted diversity outreach and recruitment efforts. The goal of technical assistance also is to achieve and maintain STEM program environments that are welcoming to more broadly diverse student bodies, ensuring greater diversity participation and retention in such programs.

Below are some of the activities that contributed to this outcome this fiscal year.

Providing students and educators with quality STEM curricular support resources and materials

The first major step to retaining students in STEM disciplines is ensuring that they have access to quality, exciting STEM opportunities, resources, and materials throughout their education. As part of this objective, NASA Education offers a variety of programs to help K–12, undergraduate, and graduate educators better use NASA resources and improve their knowledge and skills. In FY 2011, 67,245 educators participated in NASA education programs. When combined with the 27,674 faculty members who participated in NASA's national higher education programs, the Agency has successfully reached 94,919 educators along the full length of the education pipeline. Additionally, 36,312 undergraduate and graduate students and 863,879 elementary and secondary students participated in NASA education opportunities.

Helping Education grant recipients serve a diverse student body

NASA's program for reviewing civil rights compliance among its grantee institutions, such as universities and science centers, completed five institutional reviews. ODEO provided civil rights findings and recommendations to assist the institutions in enhancing their equal opportunity related efforts. Recommendations included targeted recruitment and environmental enhancements to attract and retain more diverse student bodies and appropriate signage and other program accessibility enhancements for individuals with disabilities and limited English proficiency.

NASA helps kick off FIRST Robotics Competitions in 2011

NASA, the largest sponsor of the [FIRST Robotics Competition](#), joined local, New Hampshire technology firms to launch this year's competitions at an event at Southern New Hampshire University in Manchester in January 2011.

FIRST, or For Inspiration and Recognition of Science and Technology, is a long-standing, international challenge to inspire curiosity and create interest in STEM among high school students. The event gives students the opportunity to design, build, test, and compete a robot that can perform specific functions. FIRST also gives students a crucial mentoring experience with NASA professionals, who help them explore solutions to robotics problems and understand real-world challenges faced by engineers and researchers.

NASA plays a significant role by providing public access to robotics programs to encourage young people to investigate careers in the sciences and engineering. Through the [NASA Robotics Alliance Project](#), the Agency provides grants for 297 teams and sponsors four regional student competitions, including a new FIRST regional competition in Washington, DC, for 2011. NASA engineers and scientists participate with many of these teams as technical participants and mentors to the students. Through these mentoring activities, NASA engineers are able to share their expertise and experiences to the nation's next generation of technical leaders.

During the live broadcast in January, FIRST founder Dean Kamen and designers of the annual challenge revealed the competition scenario for 2011. The estimated 30,000 student and engineering mentors, comprising the nearly 2,000 teams, then had a frenzied six weeks to design and build their robots. Each year, FIRST presents a new robotics competition scenario with twists and nuances to challenge both rookie and veteran teams. Each team receives a kit of parts and has six weeks to design and build a robot based on the team's interpretation of the game scenario. Other than dimension and weight restrictions, the look and function of the robots is up to each individual team.



The Kennedy Space Center's house FIRST team, known as the Pink Team, consists of high school students from Rockledge, Cocoa Beach, and Viera, Florida. In this photo, the Pink Team shows off its robot to Kennedy's Deputy Director Janet Petro and Engineering Director Pat Simpkins at the Florida FIRST Robotics Competition in early March. (Credit: NASA/G. Benson)

NASA's Spaced-Out Sports challenge

In May 2011, NASA announced three winners in the [Spaced Out Sports](#) competition, which challenged U.S. students in fifth through eighth grades to create games for astronauts to play aboard the [International Space Station](#). The challenge is part of a broader Agency education effort to engage students in STEM activities.

The Spaced Out Sports challenge, a Teaching from Space project, is focused on helping students learn and apply Sir Isaac Newton's Laws of Motion. Using the accompanying curriculum, teachers led students through a study of Newton's laws, highlighted by hands-on activities and video podcasts featuring NASA scientists and engineers explaining how the laws are used in the space program.

The videos also feature celebrity athletes explaining the science behind their sports. Contributors include Olympic gymnast Nastia Liukin, [NASCAR](#) driver Juan Pablo Montoya, [Women's National Basketball Association](#) player Temeka Johnson, [National Hockey League](#) player Ryan O'Reilly, and members of the [National Football League's New Orleans Saints](#).

Students learned the differences in a game played in the gravity environment of Earth and the same game played in a microgravity environment, such as the International Space Station. They used the knowledge to design or redesign a game to illustrate and apply Newton's laws.

Find out more about [this year's winners and the games they created](#).

NASA selects classroom teachers for SOFIA science flights

In May, NASA selected six teachers to work with scientists aboard the [Stratospheric Observatory for Infrared Astronomy \(SOFIA\)](#) during research flights in May and June. This was the first team of educators selected to participate in SOFIA's Airborne Astronomy Ambassadors Program. The six teachers selected for the SOFIA program submitted applications that included plans for taking their training and flight experience back to their classrooms.

SOFIA is a highly modified Boeing 747SP aircraft fitted with a 100 inch-diameter telescope. It analyzes infrared light to study the formation of stars and planets, chemistry of interstellar gases, composition of comets, asteroids and planets, and supermassive black holes at the center of galaxies. As a member of an Educator Ambassador team, teachers will fly on a SOFIA science flight and will receive training associated with the flight and the scientific research. They also will have access to scientists and educational information through electronic communications, receive an active astronomy kit, and support materials for education and outreach like brochures, bookmarks, and stickers.

Outcome 6.1					
Improve retention of students in STEM disciplines by providing opportunities and activities along the full length of the education pipeline.					
FY 2011 Performance Goal					FY 2011
Provide educators nationwide with knowledge and tools with which to inspire students in STEM fields.					6.1.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
75,000 educators participate in NASA education programs.	7ED6 Green	8ED05 Green	9ED7 Green	10ED07 Green	ED-11-3 Green
FY 2011 Performance Goal					FY 2011
Provide higher education students with authentic NASA mission-based opportunities that build knowledge and skills needed for STEM careers.					6.1.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
25,000 undergraduate and graduate students participate in NASA education opportunities.	None	None	9ED6 Green	10ED05 Green	ED-11-4 Green
FY 2011 Performance Goal					FY 2011
Provide elementary and secondary students with authentic NASA mission-based opportunities that build STEM knowledge, skills and career awareness.					6.1.2.2 Green
FY 2011 Annual Performance Goals	FY07	FY08	FY09	FY10	FY 2011
600,000 elementary and secondary students participate in NASA instructional and enrichment activities.	7ED6 Green	8ED04 Green	9ED8 Green	10ED08 Green	ED-11-5 Green
75 percent of elementary and secondary students express interest in STEM careers following their involvement in NASA education programs.	7ED4 Green	None	9ED10 Green	10ED06 Green	ED-11-6 Green
FY 2011 Performance Goal					FY 2011
Promote equal opportunity compliance and encourage promising practices among NASA grant recipient institutions through a fully-realized program of civil rights compliance reviews, policy guidance, and technical assistance.					6.1.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Equal opportunity (EO) assessment and technical assistance provided, or onsite compliance assessment performed, on-location at five STEM or STEM-related programs that receive NASA funding.	None	None	None	10WF11 Green	AMO-11-19 Green

Outcome 6.2

Promote STEM literacy through strategic partnerships with formal and informal organizations.

The complexity of meeting formal and informal education needs and requirements demands a highly collaborative approach. Through strategic partnerships, NASA [Education](#) leverages the resources and expertise of its partners, scales its investments to reach new audiences, and expands established networks. Tapping into partners' creativity and innovation helps disseminate NASA's products and services in a broader and more systematic manner to reach new users more effectively. By helping educators incorporate NASA content into school curricula or after-school programming, NASA cultivates strategic partnerships with both formal and informal education providers to promote science, technology, engineering, and mathematics (STEM) literacy.

NASA provides numerous opportunities for K–12 educators to engage directly with the science and engineering work conducted by the NASA mission directorates—helping educators meet the needs of their students in a resource-scarce environment. The high quality, inquiry-based curriculum materials for STEM learning developed by NASA mission directorates are used by teachers for formal education activities in their classrooms, and by NASA partner organizations who conduct educational activities with students in informal settings. NASA Education works with local, state, and Federal organizations to ensure that NASA's services and products provide information and opportunities that are appropriate, meet established needs, and support ongoing STEM initiatives.

Partnerships for formal education, particularly with higher education institutions and aerospace companies, focus on engineering and research efforts under the supervision of practicing professionals. These partners are able to provide independent research projects for undergraduate and graduate students and expand greatly what NASA can host at its facilities alone.

NASA's educator professional development projects provide educators with in-depth training and teaching materials on NASA mission topics that can enhance their regular classroom instruction. Subject matter experts often help Education develop the training and teaching materials and provide support through in-person presentations, online chats, or other types of interactions. Both formal and informal education partners use NASA's curricular support resources (e.g., videos, vodcasts, interactions with NASA scientists and engineers), which showcase NASA's mission activities, strengthen learners' understanding of engineering and technology innovations at NASA, and illustrate the connection between academic subjects and skills with real world applications.

Below are examples of fiscal year activities for this outcome:

NASA teams with the NRC to create science standards

In 2011, the National Research Council (NRC) of the [National Academies](#) released *A Framework for K–12 Science Education*, which specifies eight science and engineering practices that students should learn and use over the course of their schooling, such as asking questions and defining problems, analyzing and interpreting data, and engaging in argument from evidence. It is designed to bring greater coherence to the science education that students receive across grades K–12. The framework also calls for a full integration of the practices of science with the ideas and concepts. That is, students should learn the ideas of science through actually doing science. NASA [Education](#) will work with the non-profit organization identified by the NRC to create science standards that identify the key scientific practices, concepts and ideas that all students should learn by the time they complete high school, based on the framework. The new standards should be completed in late 2012.

Summer of Innovation leverages strategic partnerships to share NASA's STEM content

President Obama's "[Educate to Innovate](#)" campaign challenged the nation to foster a renewed commitment to strengthen America's literacy in science, technology, engineering, and mathematics (STEM). In response to the President's call to action, NASA launched the [Summer of Innovation \(Sol\)](#) project. Sol strategically partners with summer and other out-of-school time programs to build the capacity of school- and community-based organizations, tailors NASA support to address local needs, and facilitates the infusion of NASA content into summer and out-of-school time learning. Sol is specifically targeted at underserved and underrepresented students in grades 4–9. In 2011, NASA and Sol made

eight National Awards, partnered with more than 130 organizations and school districts through its Center awards, and distributed almost 200 Mini-Grant awards. The Sol project had a presence in 46 states, the District of Columbia, and Puerto Rico.

The Sol project design aligns with the 2010 report from the President's Council of Advisors on Science and Technology, which encourages partnerships between Federal education programs and non-profits while targeting underrepresented students. Because strategic partnerships significantly contribute to the execution and success of the Sol's implementation, the 2011 solicitation required organizations to include partnerships with a local school or school district for the purposes of increasing the potential for scalability.

In 2011, Sol made eight awards of up to \$750,000 over four years to National Awardees—large, proven providers of STEM content to Sol's targeted audiences. The selected organizations pledged to partner with school districts to provide 2,500 middle school students with forty hours of Summer of Innovation STEM activities or content during the summer and to provide 25 hours of content during the school year. To increase the STEM teaching capacity of the selected organizations and to further encourage collaboration between the formal and informal education communities, these Sol National Awards also required the participation of 150 certified teachers in delivering content to students. In addition, Sol provided forty hours of professional development to participating teachers.

NASA's Centers have extensive experience engaging local community partners in summer programming for students across the country. Sol 2011 Center Awards enhanced NASA's ability to support STEM programming through the Centers' collaborations with individual organizations or consortiums that benefited from the use of Center resources, facilities, and personnel. NASA awarded an average of \$150,000 in Sol funding to each of the nine NASA Centers and the Jet Propulsion Laboratory. In turn, each Center leveraged partnerships with schools and/or summer learning organizations to provide 20 hours of Sol STEM content to 1,500 middle school students.

Sol partnerships were also formed with small and non-traditional NASA audiences. During the pilot of the Sol project in 2010, numerous organizations expressed interest in partnering with NASA in Summer Learning. Many of the organizations that provide opportunities to the Sol target audience are community based, and do not have substantial experience in government partnerships. NASA used the mini-grant opportunity to focus on these smaller organizations across the country to introduce them to Summer of Innovation content and themes. In partnership with the National Space Grant Foundation, Sol awarded mini-grants of up to \$2,500 to sites to provide at least six hours of NASA STEM content to students or professional development to teachers during summer and out-of-school time.



Students participate in a Sol activity conducted by Tomorrow's Aeronautical Museum in Compton, California. NASA partnered with over 130 organizations for Sol in 2011 through National Awards, Center Awards, and Mini-Grants. (Credit: TAM)

NASA and the LEGO Group partner to inspire children to build and explore the future

A LEGO Space Shuttle that headed to orbit marked the November 2010 signing of a Space Act Agreement between NASA and the LEGO Group to spark children's interest in STEM. The partnership marks the beginning of a three-year agreement that will use the inspiration of NASA's space exploration missions and the appeal of the popular LEGO bricks to spur children's interest in STEM. The theme of the partnership is "Building and Exploring Our Future."

To commemorate this new relationship, the small LEGO Shuttle launched with the crew of the Space Shuttle Discovery on its final mission, which launched February 24, 2011, from NASA's Kennedy Space Center in Florida. As part of the Space Act Agreement, NASA also sent special LEGO sets to the International Space Station aboard Shuttle *Endeavour's* STS-134 mission in May 2011.

As part of NASA and the LEGO Group's partnership kickoff, the Kennedy Space Center set up a 40-by-70-foot activity tent on November 2, 2010, at the Shuttle launch viewing site on the NASA Causeway. The partners invited children of all ages to get creative and build their vision of the future with LEGO bricks. ([Read more about this story.](#))

NASA's partnership with LEGO Group couples the excitement of NASA's missions with kids' love of building with the iconic LEGO bricks. Projects with LEGO not only foster creativity and inspire the next generation of explorers, but also instill in the young builders a real sense of the engineering and design principles that NASA uses every day.

The LEGO Group has released four NASA-inspired products in their LEGO CITY line throughout 2011. In addition to the Space Shuttle, they have released a Space Moon Buggy, a Space Center, and a Satellite Launch Pad. The space-themed products vary in terms of complexity, engaging audiences from young children to adult LEGO fans. Each product contains NASA-inspired education materials. (Visit the LEGO space product site at <http://www.legospace.com/>)

The Endeavor Science Teaching Certificate Project opens doors

Educators participating in the NASA Endeavor Science Teaching Certificate Project (ESTCP) receive professional development that opens doors of opportunity for their students, as well as the educators themselves. In 2011, Endeavor Fellows had a new opportunity to use their coursework toward earning national board certification.

The Endeavor online professional development model is designed to create a national cadre of over 200 Endeavor Fellows who demonstrate leadership in the use of NASA-related STEM content within their classrooms and in educator workshops at the district, regional, and state levels. Since 2009, the NASA ESTCP has funded up to 50 educators a year to participate in online graduate courses in a live format. Throughout their individualized professional development, Endeavor Fellows explore how they will incorporate the content and best practices in their respective classes. The required Action Research Plan and Methods in STEM Education courses require participants to apply and evaluate delivery of the content and instructional methods. U.S. Satellite Laboratory, Inc., and its partners of various state departments of education administer the ESTCP.

ESTCP Fellow, Julie Gabrovic, had taught physical education for 18 years in Florida when her principal asked her if she would teach a science lab part time. To prepare for teaching science, Gabrovic subscribed to the NASA EXPRESS listserv. This listserv sends subscribers a weekly e-mail with information about NASA opportunities and teaching materials. It was through EXPRESS that Gabrovic learned of ESTCP.

In addition to the required courses, Gabrovic selected three elective courses. It was her elective course "Lessons From the Ocean" that helped open doors of opportunity for Gabrovic and her students when they participated in a Webcast—The Oilspill One Year Later—with professors from Columbia Teachers College and other NASA fellows.

Additionally, during summer 2011, Gabrovic completed an internship at NASA's God-dard Space Flight Center in Greenbelt, Maryland. The internship was the result of a proposal that she submitted for an opportunity that was only available to Endeavor Fellows. The opportunity, Formal and Informal Planetarium Earth Data Partnership, calls for the Fellow and a planetarium educator to create an interactive exhibit for their local planetarium. Gabrovic's exhibit will be based on the topic "How is the ocean an integral part of the water cycle?"



Students build launch vehicles from a pile of LEGO bricks at the "Build the Future" event held on November 3, 2010. (Credit: NASA/B. Ingalls)

Since participating in the ESTCP, Julie Gabrovic (right) has become the chair of the science department at her school and is part of the science and mathematics task force in her school district. (Credit: J. Gabrovic)



Outcome 6.2					
Promote STEM literacy through strategic partnerships with formal and informal organizations.					
FY 2011 Performance Goal					FY 2011
Provide educator professional development experiences and materials that align to needs and opportunities identified by districts, states, Department of Education, professional organizations, and other stakeholders.					6.2.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
5,000 educators use NASA resources in their curricula after participating in NASA professional development.	7ED6 Green	8ED05 Green	9ED7 Green	10ED07 Green	ED-11-7 Yellow
	None	None	9ED9 Green	10ED09 Green	
Why NASA rated APG ED-11-7 Yellow: The ability to collect data from educators who have participated in NASA professional development is highly dependent upon those educators' response rates to follow-up surveys. Currently, NASA sends follow-up surveys to educators who have participated in an Agency-sponsored professional development program via e-mail, 120 days after the educator's experience. Tens of thousands of educators participate in NASA's programs, but only a small percent complete and submit the follow-up surveys. In FY 2011, less than 5,000 educators replied to the survey. NASA is generally able to establish and maintain ongoing relationships with higher education faculty because it is not difficult to obtain the necessary data on their use of NASA resources in their curricula. However, this proves to be extremely difficult with most K-12 and informal educators. Based on this, NASA continues to improve data collection methods. (See page 157 for the Performance Improvement Plan.)					
FY 2011 Performance Goal					FY 2011
Provide expertise in the development of STEM education policies and strategies.					6.2.1.2 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Provide expertise to support the National Academies development of a framework for integrated science and engineering standards.	None	None	None	None	ED-11-8 Green

Outcome 6.3

Engage the public in NASA's missions by providing new pathways for participation.

NASA encourages active participation in the Agency's programs and Mission, consistent with the philosophy of government transparency. Participatory engagement seeks to include the public in the adventure and excitement of NASA's activities and tap into individual creativity and capabilities to enhance its work in science, discovery, and exploration.

NASA's participatory engagement activities, led by the Office of Communications, span the communications spectrum ranging from passive activities—like watching online NASA videos—to highly interactive activities that use NASA-related social media tools or provide hands-on experiences. NASA also uses these activities to collaborate with the public on interpretation of data and discoveries. By increasing the mechanisms through which the public can directly and specifically contribute to NASA's missions, the Office of Communications can bring additional creativity and capability to some of the biggest challenges, and leverage NASA's resources to accomplish more toward the Agency's goals.

Below is a summary of fiscal year activities for this outcome:

Using new technologies to reach the public

Some people may choose to participate simply by watching [NASA Television](#) or by visiting a NASA exhibit. Others choose to communicate with NASA via [Twitter](#) or Facebook, and actively participate in NASA events such as Tweet-ups. Still others form teams to enter NASA challenges. By 2015, NASA's goal is to establish a portfolio of participatory engagement opportunities throughout the Agency.

In FY 2011, the NASA Office of Communications began creating a process to identify and promote participatory engagement activities across the Agency, the first step toward establishing a baseline of activities. Each NASA program and mission would be encouraged to build some participatory engagement opportunities into their program design, and the Office of Communications will help each program and mission promote those opportunities to the appropriate audience.

The Office of Communications will compile its findings about participatory engagement into a report to the [Office of Management and Budget](#) as part of a review process for future submission to Congress, per Section 408 of the NASA Authorization Act of 2008.

NASA's iPad app beams science straight to users

NASA satellites beam data from space; now the Agency is beaming it straight to iPads, placing NASA Earth science in the public's hands.

In July 2011, software and media specialists at the NASA [Goddard Space Flight Center](#) released a new iPad app—the [NASA Visualization Explorer](#)—that allows users to easily interact with extraordinary images, video, and information about NASA's latest Earth science research. The app's science features include high-resolution movies and stills and short written stories to put all the pieces in context. Most of the movies are simply real satellite data, visualized. Other features include interviews with scientists and imagery from supercomputer modeling efforts.

NASA's iPad app makes science from NASA's research efforts widely accessible in an engaging, easy-to-consume, thoroughly modern style. The visualization capabilities of the app add meaning to the often intangible, but essential data delivered from NASA research.

Work began on the NASA Visualization Explorer shortly after Apple released its electronic tablet in April 2010. The design team for the application's user interface knew immediately that the iPad provided the perfect platform to showcase NASA science.



The NASA Visualization Explorer (shown here) joins NASA's other free iPad apps, all released in 2011: AstroApp: Space Shuttle Crew, NASA Television, AstroApp: Space Station Crew, and NASA Desert RATS Virtual Test Site. (Credit: NASA)

The app, which is free from the iTunes App Store, includes social networking interfaces, like links to Facebook and Twitter for easy sharing of stories.

TEDxNASA comes to the west coast

On August 17, 2011, [TEDxNASA@SiliconValley](#) became the Agency's first such event held on the west coast. Held in San Francisco, this independently organized event was in the spirit of the [TED \(technology, entertainment, and design\)](#) conferences that bring together leading thinkers to create a dialogue about important global challenges.

Attendees and visitors at TEDxNASA@SiliconValley gathered to discuss the theme "Extreme Green." Those who could not attend on site could participate online with chat and streaming video. The goal of TED events is to bring together people with diverse backgrounds and points of view, and the August event lived up to this goal by hosting a genome scientist, an environmental visionary, an astronaut/engineer, a test pilot, a filmmaker, a singer/songwriter, and many others.



Visitors at TEDxNASA@SiliconValley pass by rows of monitors, including one showing images taken by the [Solar Dynamics Orbiter \(SDO\)](#). (Credit: TEDxNASA)

Representatives from Center Media and Public Relations Offices, which serve the Office of Communications, coordinate the events with partners from professional organizations and industry. Visit the [TEDxNASA](#) site for information about upcoming and past events.

Outcome 6.3					
Engage the public in NASA's missions by providing new pathways for participation.					
FY 2011 Performance Goal					FY 2011
By 2015, establish an Agency-wide portfolio of participatory engagement opportunities.					6.3.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Identify candidate mechanisms to encourage public engagement in NASA programs and missions.	None	None	None	None	AMO-11-20 Green

Outcome 6.4

Inform, engage and inspire the public by sharing NASA's missions, challenges, and results.

The opportunities and means for sharing information have increased tremendously with the Internet, social media, and other new technologies. For scientific and programmatic announcements, NASA continues traditional communications activities like issuing press releases, hosting media events, and providing photographs and videos of missions and events. Additionally, the Office of Education, the Office of Communications, and the mission directorates are expanding their content to reach more diverse audiences. For example, interactive experiences with astronauts, scientists, and engineers, through an online presence and other outreach events, are well-suited for engaging the public and students. As discussed in Outcome 6.3, the Office of Communications is taking advantage of recent and emerging technologies and media (Tweetups, live streaming video, social media) to deliver NASA information to a more diverse audience.

NASA's education strategy includes a targeted effort to refresh current linkages and develop new ties with the education community, Federal agencies, corporations, and nonprofit organizations to infuse NASA's science, technology, engineering, and mathematics (STEM) content into classrooms and beyond. NASA promotes STEM literacy and awareness of its mission through strategic partnerships and linkages between formal and informal education providers. The Office of Education partners with industry stakeholders, academic institutions, museums, science centers, planetariums, Challenger Centers for Space Science Education, and other Federal agencies like the Department of Education.

NASA shares the direct results of its missions by releasing scientific data to researchers and other government agencies. The Agency contributes data to online portals like <http://www.data.gov>, allowing its use by anyone with the capability to access it. NASA Web sites host a wealth of mission and program information, and NASA participates fully in Administration initiatives for transparency by providing specific program and project information through information-sharing portals.

Below are some of the activities that contributed to this outcome:

Space Shuttle launch provides unique event opportunity for students and NASA Education

In conjunction with the final Space Shuttle flight, STS-135, the Office of Education used a cutting edge style of conference developed by tech companies to gather feedback from its constituents called an "unconference." An unconference has no set agenda or prescribed desired outcome. Instead, the participants (in this case students) rather than the organizers guide the discussions, encourage creative interaction, and debate among the attendees. NASA invited 200 affiliated high school, undergraduate and graduate students to attend the STS-135 unconference, held the day before the launch of STS-135, July 8, 2011, at the Marriott World Center in Orlando, Florida. Students came from 20 states, the farthest being Alaska.

The unconference was a listening exercise for NASA, allowing Education and other NASA leaders to learn about students' interests and vision for the future of NASA and the U.S. space program. There were four specific interest areas the students discussed: aeronautics, space exploration, robotics, and technology. NASA invited subject matter experts both from NASA and organizations specializing in each area to work with NASA Education facilitators and NASA Student Ambassadors to answer students' questions and to facilitate a free form conversation. Throughout the day, sessions became quite spirited with students debating the finer points of the various subject areas.



(Left) A college student listens intently during the Subject Matter Experts' Reflections panel at the STS-135 Unconference. (Right) NASA Associate Administrator for Education, Leland Melvin, provided closing remarks at the STS-135 Unconference. As a NASA Astronaut who has flown on two space shuttle missions, Melvin serves as an inspirational leader and role model to encourage students in their pursuit of STEM-related studies. (Credit, both photos: Corporate Visual Services/ T. Cuffel)





Hundreds of thousands of visitors—students, educators, and families—explore NASA science and technology every year at the NASA visitor centers. Located near or on the site of each of NASA's 10 Centers, each visitor center conveys the NASA story through each Center's unique contributions. In the Jet Propulsion Laboratory's visitor center, full-scale spacecraft models take visitors on a tour of Earth, the solar system, and the universe through each robotic explorer's experiences: Galileo to Jupiter; Voyager 1 and 2 to Jupiter, Saturn, Uranus, Neptune, and beyond; and Mars Pathfinder and the Mars Exploration Rovers across the Red Planet's surface. Visitors can get up close and personal with meteorites from asteroid Vesta (currently being explored by NASA's Dawn spacecraft), and an interactive model of a Deep Space Network tracking antenna. Tour guides use a giant multi-touch screen to demonstrate scale in the solar system, the electromagnetic spectrum, and facilities at the Jet Propulsion Laboratory. Visitors also can watch over 70 engaging videos at stations around the room and explore scale models of the planets and other spacecraft. (Credit: NASA/JPL-Caltech)

Once the breakout sessions were complete, the invited subject matter experts lead a reflection panel and provided to the students feedback on the day's discussions. This led to a discussion about how NASA could further students' interest in STEM studies.

The following day, all 200 students and approximately 400 VIP Office of Education guests attended the final launch of the Space Shuttle, STS-135.

Delivering information to the public—faster and better

By using social media tools and direct interaction with stakeholders, NASA is able to listen to the American taxpayer, as well as inform them about NASA missions and challenges. Through traditional and emerging tools, NASA broadly shares timely, accurate and consistent information, and promotes and open, transparent government. NASA is working to coordinate its activities across the Agency through a framework, governance model, implementation plan and portfolio for all NASA communications activities. Furthermore, NASA is complying with federal laws and regulations for the Freedom of Information Act (FOIA), under which the public can request records from Federal agencies. In FY 2011, NASA reduced the backlog of FOIA responses by 25 percent. The improvement is due to collaboration, streamlining the program and processing in accordance with the law. The elimination of the backlog allows NASA's FOIA Office to address and process all requests immediately within the constraints of the law.

NASA joins USA Science & Engineering Festival in Washington

NASA joined more than 500 science organizations in late October 2010 to inspire the next generation of scientists and engineers during the first national science and engineering festival to be held in the Nation's capital.

The USA Science & Engineering Festival began with activities in local schools and ended with a two-day expo on the National Mall and surrounding areas. The event also marked the culmination of NASA's new Summer of Innovation pilot education initiative, aimed at engaging middle school students in STEM activities during the summer break. The program reached more than 75,000 middle school students during its inaugural year.

The festival was a dynamic way to reach and excite students and the general public about NASA many scientific missions. Booths at the



During a 2011 Summer of Innovation camp, hosted by Langley Research Center and the Thomas Nelson Community College's Williamsburg campus, a young rocketeer builds her rocket. NASA Langley's informal education team worked with children from Big Brothers/Big Sisters organization to build and launch the rockets. (Credit: NASA/S. Smith)

expo featured hands-on activities, demonstrations, and exhibits that brought exploration and discovery to life. Students also learned how to become involved in 2011 Summer of Innovation events. The Summer of Innovation pilot program, which began in June, used the same successful approach to engage middle school students across the Nation in STEM activities.

Bringing NASA to the public

In FY 2011, 421 museums and science centers across the country actively engaged the public in major NASA events. Much of this engagement was facilitated through NASA's Museum Alliance, a free-of-charge NASA STEM content facilitation service and online education community. The Museum Alliance offers educators real-time NASA information for use with all visitors to informal education institutions.

Astronomy Day at the State Museum of Nebraska

Visitors to the State Museum of Nebraska on May 7, 2011, found some very modern items among the museum's existing dinosaur exhibit—several NASA telescopes. The museum's Astronomy Day featured a unique opportunity for over 500 visitors to see the telescopes and receive demonstrations of how they work.

The NASA Museum Alliance, which made the museum's Astronomy Day possible, gives visitors access to current NASA science and technology by loaning NASA materials to museums. The Museum Alliance also provides the museum's staff professional development and access to NASA scientists and engineers. Over 800 professionals at more than 420 U.S. museums, science centers, planetariums, NASA Visitor Centers, Challenger Centers, observatories, parks, nature centers, zoos, and aquariums are partners in the Museum Alliance. Museum Alliance partners present a variety of space exploration and aeronautics programs and events—exhibits, planetarium shows, educator workshops, and special lectures—for their local communities.



A guide at the State Museum of Nebraska shows a NASA telescope to visitors. (Credit: J. Dunn, University of Nebraska, Lincoln, Ralph Mueller Planetarium)

Outcome 6.4					
Inform, engage, and inspire the public by sharing NASA's missions, challenges, and results.					
FY 2011 Performance Goal					FY 2011
Leverage communities of practice to facilitate sharing of NASA successes and challenges with the public.					6.4.1.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
420 museums and science centers across the country actively engage the public in major NASA events.	None	8ED06 Green	9ED11 Green	10ED10 Green	ED-11-9 Green
FY 2011 Performance Goal					FY 2011
Use current and emerging communications technologies to reach increasingly broad audiences.					6.4.2.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Establish an Agency-wide portfolio of communication tools.	None	None	None	None	AMO-11-21 Green
FY 2011 Performance Goal					FY 2011
Make available Agency records through the Freedom of Information (FOIA), Privacy Act, and Open Government Initiative in accordance with federal laws and regulations.					6.4.3.1 Green
FY 2011 Annual Performance Goal	FY07	FY08	FY09	FY10	FY 2011
Issue Agency-wide Freedom of Information Act (FOIA) tools to support consistent responses to requesters.	None	None	None	None	AMO-11-22 Green

Introduction

Performance Improvement Plans

Performance Improvement Plans by Category

This section provides the explanations and performance improvement plans for any unmet performance measures in FY 2011 and, where applicable, their link to the previous year's performance.

When a NASA program does not meet its commitment as stated in the annual performance plan, responsible program officials must explain the performance shortfall and provide an improvement plan for correcting the issue. This year, in an effort to provide better performance improvement plans, NASA assessed the explanations and looked for trends in root causes, to inform senior management on any cross-cutting corrective actions that may be warranted. In addition, NASA used the information on management and performance challenges, as identified by the NASA's Office of Inspector General (OIG) and the Government Accountability Office (GAO), to help guide setting these improvement plans.

In FY 2011, NASA's OIG identified five areas that pose the top management and performance challenges to NASA leadership: the future of U.S. space flight, project management, infrastructure and facilities management, acquisition and contracting management, and information technology security and governance. GAO previously identified high risk factors along the same vein, including managing information technology, antiquated financial management systems, poor cost estimating, underestimated risks associated with development of major systems, and inadequate acquisition management in view of persistent cost growth and schedule slippage in the majority of projects. More information on OIG and GAO assessments of NASA can be found in the Management Challenges letter from NASA's OIG located in this report (see page 247) and on the GAO High Risk Web site.

With the themes presented by OIG and GAO in mind, NASA categorized the measures and information on their shortfalls to provide context to the reader for why groups of measures may have been unmet. NASA has placed its performance shortfalls, and ensuing improvement plans into the following categories:

- Measures Requiring Improved Measurement Methods (page 157)
- Energy Use Management (page 158)
- Safety of Workforce and Assets (page 160)
- Taurus XL Launch Vehicle Failure (page 162)
- Commercial Space Flight Development (page 165)
- Human Spaceflight Program Transition (page 167)
- Scientific Research and Technology Development Process (page 171)
- Baseline Cost and Schedule Changes (includes sub-categories on acquisition management challenges, and program planning and controls, page 175)
- Workforce, Workplace, and Diversity (page 182)

Looking forward, NASA will build upon the progress already made within some of these categories, such as corrective actions to mitigate cost growth and schedule slippage. Specifically, over the last five years, NASA fundamentally transformed how it manages its programs and projects, acquisition strategies, and procurements, including strengthening program and project management, establishing more rigorous cost estimation practices, and revising procurement practices and systems.

In subsequent years, NASA will track progress toward these plans and analyze the performance improvement trends in an effort to strengthen Agency performance.

Measures Requiring Improved Measurement Methods

NASA has an integrated system to plan strategy and implementation; monitor, assess, and evaluate performance toward commitments; identify issues; gauge programmatic and organizational health; and provide appropriate data and information to NASA decision-makers. NASA's planning and performance management processes provide data to Agency management through ongoing monthly and quarterly analyses and reviews; annual assessments in support of budget formulation (for budget guidance and issue identification, analysis, and disposition); annual reporting of performance, notification of management issues, and financial position; periodic, in-depth program or special purpose assessments; and recurring or special assessment reports to internal and external organizations. To ensure that these performance assessments provide the necessary information, NASA periodically revisits the effectiveness of its measures. Sometimes NASA identifies issues with the design of a measure, the method of data collection, or the practicality of a performance target, as well as some inaccuracies in metrics. This fiscal year, data collection methods for two measures did not yield enough information to accurately measure performance. NASA plans to improve on these data collection methods.

Fiscal Year 2011 Performance Improvement	ST-11-15 (Performance Goal 3.4.1.3)	
	Accountable Organization: Innovative Partnerships Program	
	Greater than 35 percent of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase II technology projects awarded between 2004-2008 will be transferred into commercial products or services.	FY 2011 Red
	Why Measure ST-11-15 was Not Met: Based on NASA's current measurement method, NASA determined that it awarded 23.7% of SBIR/STTR projects (182 of 766) between 2004 and 2008 and had extended them past Phase II. NASA believes the numbers of commercialization successes are greater than the current methods indicate. To achieve commercialization, these projects used either NASA Phase III funds or an alternative source of non-NASA funding to develop the technology. Commercialization is a metric broadly defined by the SBA as a measure of the ability of SBIR/STTR contractors to successfully receive non-SBIR/STTR revenues for broad market, as well as other government applications, for technologies they developed under the SBIR/STTR programs. At NASA, this is defined as the sum of technology "infused" into NASA programs (metric 3.1.1.4), procured by other government agencies, and/or used in the commercial marketplace. The collection of non-NASA applications for this metric requires the voluntary sharing of information by SBIR/STTR contractors with NASA personnel. NASA continues to consider alternative methods of data collection that will lead to increasing accuracy in the measurement of commercialization successes.	
FY 2011 Performance Improvement Plan: To acquire a greater amount of verifiable data, the SBIR/STTR program has instituted a survey as part of its 2011 SBIR/STTR solicitation requiring firms submitting proposals to share information with NASA on their success at commercializing technologies developed under previous SBIR/STTR awards. Data from this survey will be collected and analyzed in FY 2012. NASA plans to continue to use surveys in future SBIR/STTR solicitations so that NASA can compile a database of past commercializations, and when combined with infusion data on NASA programs (metric 3.1.1.4), provide a more accurate accounting of the commercialization data requested in metric 3.4.1.3.		
Fiscal Year 2011 Performance Improvement	ED-11-7 (Performance Goal 6.2.1.1)	
	Accountable Organization: Office of Education	
	5,000 educators use NASA resources in their curricula after participating in NASA professional development.	FY 2011 Yellow
	Why Measure ED-11-7 was Not Met: The ability to collect data from educators who have participated in NASA professional development is highly dependent upon those educators' response rates to follow-up surveys. Currently, NASA sends follow-up surveys to educators who have participated in an Agency-sponsored professional development program via e-mail, 120 days after the educator's experience. Tens of thousands of educators participate in NASA's programs, but only a small percent complete and submit the follow-up surveys. In FY 2011, less than 5,000 educators replied to the survey. NASA is generally able to establish and maintain ongoing relationships with higher education faculty because it is not difficult to obtain the necessary data on their use of NASA resources in their curricula. However, this proves to be extremely difficult with most K-12 and informal educators. Based on this, NASA continues to improve data collection methods.	
FY 2011 Performance Improvement Plan: NASA plans to explore more effective means for collecting follow-up data from educators who participate in Agency-sponsored professional development. This includes potentially decreasing the 120-day follow-up period, making the submission of survey responses a prerequisite for gaining continued access to certain curricular tools, or possibly direct follow-up by phone or focus group. NASA will also consider creative ways to possibly incentivize educators to submit completed surveys. NASA Education is currently collaborating with OMB to identify ways to strengthen the Agency's surveying techniques and overall data collection methods.		

Energy Use Management

Since the mid-to-late 1980s, NASA has worked to reduce energy usage in its institutional buildings and mission installations. NASA made significant progress in meeting previous requirements (National Energy Conservation Policy Act, Federal Energy Management Improvement Act of 1988, and Energy Policy Act of 1992) to reduce energy intensity from an FY 1985 baseline. NASA implemented many of the high-yield investments that led to significant decreases in energy intensity, before statutory and executive order changes (Energy Policy Act of 2005 and Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management), adopted an FY 2003 baseline year for further energy intensity reduction. Additionally, Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance (2009), expanded upon the energy reduction and environmental performance requirements of E.O. 13423. The Agency will continue to improve our performance against targets for energy intensity, factoring all these requirements.

The performance measures below show the trend for energy intensity across a couple of years and NASA's plans for continuing to reduce it annually.

Fiscal Year 2010 Performance Improvement	10FAC04	FY 2010 Red
	Accountable Organization: Office of Strategic Infrastructure	
	Reduce energy intensity for facility energy use by 3% per year, from the FY 2003 baseline, for a total reduction of 30% (in Btu/gsf) by the end of FY 2015.	
	Why Measure 10FAC04 was Not Met: Energy intensity decreasing average of 1 percent annually and energy unit costs are increasing an average of 7.2 percent annually.	
	FY 2010 Performance Improvement Plan: NASA is working to meet energy intensity reduction requirements of 3 percent per year and 30 percent by 2015, from the FY 2003 baseline. In an effort to assist Centers to administer their energy management programs, NASA Headquarters conducts Energy and Water Management Functional Reviews at a third of NASA Centers annually to help Centers improve their management systems and identifying and implementing energy conservation measures. In FY 2010, NASA invested \$66 million for construction and revitalization projects at four NASA Centers that include major replacements of aging high energy use equipment with new energy efficient units, and initiated an Inter-Center Competition to reduce energy/water consumption. The competition encourages Centers to implement low-cost and no-cost initiatives to reduce energy and water usage. NASA will allocate \$4 million of Strategic Institutional Investment funds for small energy and renewable projects in FY 2011 and an additional \$22.3 million in FY 2012. This past fiscal year, NASA also initiated a Recapitalization Program that will replace aging facilities with new more energy efficient buildings.	
	Plan Update: NASA's progress is outlined below in the explanation and performance improvement plan for this same measure, which was reported on in FY 2011, as well.	
Fiscal Year 2011 Performance Improvement	Performance Goal 5.2.3.2	FY 2011 Yellow
	Accountable Organization: Office of Strategic Infrastructure	
	HPPG: Conserve valuable natural resources by reducing NASA's energy and water use.	
	Why Performance Goal 5.2.3.2 was Not Met: Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA expects to exceed its targets on the measures related to water use and fleet management, but fall short on the energy intensity goals. See rating explanation for ECR-11-1 for more detailed information on the energy intensity measure.	
	FY 2011 Performance Improvement Plan: Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA reduced energy intensity by an estimated 1%, for an 8% reduction from 2003 baseline. The FY 2011 goal was 18% from the 2003 baseline and NASA expects to reduce energy intensity by 10% (+/- 2%) in that same timeframe. Recent NASA topline budget reductions lowered funding planned for specific energy efficiency measures and new building construction, restoration and rehabilitation, which negatively impacted NASA's energy conservation program and reduced chances of meeting federal requirements. Despite the reduced funding, NASA continues to work to reduce energy intensity, and during FY 2010/FY 2011, the Agency completed construction and received LEED certification for 12 new buildings (1 Certified, 2 Silver, 6 Gold, and 3 Platinum). Three completed buildings are under review for certification (2 Silver and 1 Gold), and ten more buildings are under construction seeking LEED certification of Silver or Gold level in FY 2012. Eleven buildings are in the design phase for Silver or Gold LEED level.	

Fiscal Year 2011 Performance Improvement	ECR-11-1 (Performance Goal 5.2.3.2)	
	Accountable Organization: Office of Strategic Infrastructure	
	Reduce energy intensity use annually by three percent from an FY 2003 baseline.	
	<p>Why Measure ECR-11-1 was Not Met: Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA reduced energy intensity by an estimated 1%, for an 8% reduction from 2003 baseline. The FY 2011 goal was 18% from the 2003 baseline and NASA expects to reduce energy intensity by 10% (+/- 2%) in that same timeframe. Recent NASA topline budget reductions lowered funding planned for specific energy efficiency measures and new building construction, restoration, and rehabilitation, negatively impacting NASA's energy conservation program and reducing chances of meeting Federal requirements. Despite the reduced funding, NASA continues to work to reduce energy intensity, and during FY 2010–FY 2011, the Agency completed construction and received LEED certification for 12 new buildings (1 Certified, 2 Silver, 6 Gold, and 3 Platinum). Three completed buildings are under review for certification (2 Silver and 1 Gold), and ten more buildings are under construction seeking LEED certification of Silver or Gold level in FY 2012. Eleven buildings are in the design phase for Silver or Gold LEED level.</p> <p>FY 2011 Performance Improvement Plan: To continue efforts to reduce energy consumption and improve NASA's aging infrastructure, the Agency designs and constructs new buildings to minimum LEED Silver standard. NASA is evaluating co-generation such as Combined Heat and Power (CHP) project at four Centers that have district type utility distribution systems. These large projects will reduce energy consumption, use waste heat to generate energy, and provide energy security. NASA is increasing energy savings performance contract (ESPC)/utility energy service contract (UESC) projects at Centers and has created a position at Headquarters to support Centers with implementation and execution of these complex projects. The Agency has two UESC projects under way and has three additional UESCs under consideration. NASA is also executing four ESPCs at Centers and is reviewing two additional project opportunities. Additionally, NASA has performed an Agency survey for renewable energy project opportunities and is evaluating the final report for project identification. The Agency has applied for in-kind EUL authority with the FY 2012 budget request to implement large renewable energy projects.</p>	FY 2011 Red

Safety of Workforce and Assets

NASA continues to have Safety as a core value. As stated in the 2011 NASA Strategic Plan, “NASA’s constant attention to safety is the cornerstone upon which we build mission success. We are committed, individually and as a team, to protecting the safety and health of the public, our team members, and those assets that the Nation entrusts to the Agency.” For years, NASA has maintained high goals for safety and statistically exceeds much of the federal government on aspects such as lost time due to work-related injuries and illnesses. These standards are maintained despite the risky nature of spaceflight and the unique challenges it poses. The Agency has taken a “holistic” approach to addressing all the aspects of safety for the public, NASA employees, contractors and partners, and assets. Measures are tracked internally with senior management on a monthly basis, and key indicators are reported externally, including in the annual performance report. New policies, procedures, and corrective actions are implemented as specific issues or undesirable trends are seen in the data.

The table below demonstrates several key indicators where NASA did not meet its targeted goals and how performance toward these will be improved.

Fiscal Year 2010 Performance Improvement	Outcome AS.4	FY 2010 Yellow
	Accountable Organization: Office of Safety and Mission Assurance	
	While promoting mission success, protect the public, NASA workforce, high-value equipment and property from potential harm as a result of NASA activities and operations by factoring safety, quality, risk, reliability, and maintainability as integral features of programs, projects, technologies, operations, and facilities.	
	Why Outcome AS.4 was Not Met: There were 12 permanent partial disability (Type B) mishaps that occurred to contract employees during FY 2010.	
	FY 2010 Performance Improvement Plan: Policy and procedures are currently in place to provide guidance and education to the NASA workforce (civil service and contractor employees) to minimize mishaps. Management is provided an out brief after each Type A or B mishap with the goal of disseminating information that will reduce the potential for future occurrences.	
Fiscal Year 2010 Performance Improvement	Plan Update: In FY 2010, there were no NASA Type A or NASA Type B injuries for the NASA civil servant workforce and zero injuries or fatalities for the public. For FY 2010, there were 14 contractor Type B mishaps (after final Office of Workers Compensation Programs review and approval). For FY 2011, there were 10 type B contractor injuries reported, (an improvement (reduction) of 29%) from FY 2010. There was also a reduction by 50% in the amount of falls. There were no NASA Type A or NASA Type B injuries for the NASA civil servant workforce and zero injuries or fatalities for the public. But based on the number of Type B mishaps seen for contractors, and to assure continued performance against the goal, NASA Injury statistics were reviewed for trends and awareness campaigns were developed as needed. Based on the unfavorable trend of fall mishaps, a fall protection campaign was developed at the NASA Safety Center along with fall prevention campaigns at the Centers.	FY 2010 Red
	10SMS02	
	Accountable Organization: Office of Safety and Mission Assurance	
	Assure no fatalities or permanent disabling injuries to the NASA workforce resulting from NASA activities during the fiscal year.	
	Why Measure 10SMS02 was Not Met: There were no fatalities or permanent, total disabilities (Type A) to the NASA workforce during the fiscal year. However, there were 12 permanent partial disability (Type B) mishaps that occurred to contract employees. This was an increase compared to the previous year. There were no Type A or B injuries to NASA civil service employees. NPR 8621.1 defines a Type A mishaps as a permanent total disability and Type B as an occupational injury and/or illness that has resulted in a permanent partial disability.	
Fiscal Year 2010 Performance Improvement	FY 2010 Performance Improvement Plan: Policy and procedures are currently in place to provide guidance and education to the NASA workforce (civil service and contractor employees) to minimize mishaps. Management is provided an out brief after each Type A or B mishap with the goal of disseminating information that will reduce the potential for future occurrences.	FY 2010 Red
	Plan Update: In FY 2011, there were zero fatalities and permanent disabling injuries to the public and NASA civil servant workforce. Based on a review of trends of FY 2011 mishaps and close calls, NASA will be implementing an awareness campaign on Electrical Safety, and what Occupational Safety and Health Administration calls Control of Hazardous Energy, which includes Lockout/Tag out. NASA adjusted this measure in FY 2011 to incorporate reporting against the President’s POWER initiative.	

Fiscal Year 2011 Performance Improvement	AMO-11-10 (Performance Goal 5.2.1.2)	
	Accountable Organization: Office of Safety and Mission Assurance	
	Reduce Total Case Rate and Lost Time Case Rate by one percent, in accordance with the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative.	FY 2011 Red
	Why Measure AMO-11-10 was Not Met: At year-end, NASA was about 2 times lower (better) than the President's Protecting our Workers & Ensuring Reemployment (POWER) goal for TCR and 5 times lower (better) than the POWER goal for LTCR. However, NASA undertook a stretch goal of lowering the Agency's already low rates by 1%, from the POWER baseline goal year (FY 2009). The data for this calculation is current through the third quarter (fourth quarter data is not available until December), with end-of-year projections by the Department of Labor's Office of Workers' Compensation Programs, who must validate and accept these cases, that place NASA at small upswings in both TCR and LTCR from the FY 2009 base year (thus missing the 1% internal goal). Even with the slight upswings, NASA still remains one of the best in the government, and still significantly below (better than) the POWER goals.	
FY 2011 Performance Improvement Plan: Since NASA's rate already exceeded (better than) the Presidents POWER initiative and is one of the lowest in the government, NASA did not take any global initiatives to reduce this already excellent rate. However, spot initiatives were developed field center by field center to address specific trends in lost time and close call incidents.		
Fiscal Year 2011 Performance Improvement	Performance Goal 5.2.1.3	
	Accountable Organization: Office of Safety and Mission Assurance	
	By 2015, reduce damage to NASA assets by eight percent from the 2010 baseline.	FY 2011 Red
	Why Performance Goal 5.2.1.3 was Not Met: NASA does not anticipate meeting this performance goal by 2015, due to the Glory launch vehicle mishap, in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, irrespective of no damage beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals, that also feed this performance goal.	
FY 2011 Performance Improvement Plan: NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective action will be taken as needed.		
Fiscal Year 2011 Performance Improvement	AMO-11-11 (Performance Goal 5.2.1.3)	
	Accountable Organization: Office of Safety and Mission Assurance	
	Reduce damage to NASA assets by two percent per fiscal year, based on a five-year running average.	FY 2011 Red
	Why Measure AMO-11-11 was Not Met: NASA does not anticipate meeting this performance goal by 2015 due to the Glory launch vehicle mishap in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, even if there is no damage to any other NASA assets beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals that also feed this performance goal.	
FY 2011 Performance Improvement Plan: NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective action will be taken as needed.		

Additional Context

Performance Goal 5.2.1.2: *By 2015, achieve a four percent reduction in the total case rate and lost time rate for the NASA civil service work force* is rated Green. NASA expects to remain on track for this performance goal under the current extrapolated projection, based on past trends.

Taurus XL Launch Vehicle Failure

The Glory Earth-observing satellite was intended to improve our understanding of how the Sun and tiny atmospheric particles called aerosols affect Earth's climate. On March 4, 2011, Glory launched from Vandenberg Air Force Base in California. The countdown and launch went smoothly until the point at which the fairing should have separated from the vehicle. Telemetry indicated that the launch vehicle failed because the fairing, the protective shell atop the rocket, did not separate as expected about three minutes after launch, and as a result the launch vehicle did not deliver the Glory spacecraft to orbit. NASA has created a Mishap Investigation Board to evaluate the cause of the failure.

NASA's previous launch attempt of an Earth science spacecraft, the Orbiting Carbon Observatory onboard a Taurus XL on February 24, 2009, also failed to reach orbit when the fairing did not separate. NASA's Orbiting Carbon Observatory Mishap Investigation Board reviewed the launch data and the fairing separation system design and developed a corrective action plan. The plan was implemented by Taurus XL manufacturer Orbital Sciences Corporation. In October 2010, NASA's Flight Planning Board confirmed the successful closure of the corrective actions.

This second launch failure had far reaching impacts on NASA's reported performance. Multiple measures demonstrate the impact of the Glory launch mishap, which is reflective of how NASA works in an integrated manner, across multiple organizations, to ensure mission success. Since 1998, NASA has averaged a 97 percent mission success rate for all missions using expendable launch vehicles. The Office of Safety and Mission Assurance supports this success rate through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, and quality assurance policies and procedures. The Human Exploration and Operations Mission Directorate's Launch Services Program (LSP) works closely with other U.S. government agencies and the launch industry to ensure that the most safe, reliable, on-time, cost-effective commercial launch opportunities are available on a wide range of launch systems. The Science Mission Directorate develops and manages these missions and works with LSP to match their requirements with the appropriate reliable and available launch vehicle.

NASA will consider the results of the investigation when determining the next steps for providing reliable mid-sized launch services for NASA science missions. The lessons from addressing this mishap will respond to how all of these organizations continue to work together to ensure future mission success, which is reflected in the performance improvement plans outlined below.

Mission Assurance and Launch Rate Success		
Fiscal Year 2011 Performance Improvement	Performance Goal 5.2.1.3	
	Accountable Organization: Office of Safety and Mission Assurance	
	By 2015, reduce damage to NASA assets by eight percent from the 2010 baseline.	
	Why Performance Goal 5.2.1.3 was Not Met: NASA does not anticipate meeting this performance goal by 2015, due to the Glory launch vehicle mishap in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, even if there is no damage to any other NASA assets beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals that also feed this performance goal.	
	FY 2011 Performance Improvement Plan: NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective action will be taken as needed.	
		FY 2011 Red

Fiscal Year 2011 Performance Improvement	AMO-11-11 (Performance Goal 5.2.1.3)	
	Accountable Organization: Office of Safety and Mission Assurance	
	Reduce damage to NASA assets by two percent per fiscal year, based on a five-year running average.	FY 2011 Red
	Why Measure AMO-11-11 was Not Met: This annual performance goal will not be met in FY 2011, due to the failure of the Taurus XL launch vehicle which resulted in the loss of the Glory mission. Based on the magnitude of the cost of the loss of the Glory mission, FY 2011 will see a growth from FY 2010, rather than a reduction.	
FY 2011 Performance Improvement Plan: NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective actions will be taken as needed.		
Fiscal Year 2011 Performance Improvement	SFS-11-2 (Performance Goal 5.4.1.1)	
	Accountable Organization: Human Exploration and Operations Mission Directorate, Launch Services Program	
	Sustain 100 percent success rate with the successful launch of NASA-managed expendable launches as identified on the Launch Services Flight Planning Board manifest.	FY 2011 Yellow
	Why Measure SFS-11-2 was Not Met: This annual performance goal was not met due to the loss of the Glory mission. NASA's Glory satellite did not reach orbit after its liftoff on March 4, 2011, due to a launch vehicle mishap. The Launch Services Program successfully launched the other three missions scheduled for this fiscal year. Aquarius successfully launched aboard a Delta II launch vehicle on June 10, 2011 from Vandenberg Air Force Base, CA. The Juno mission launched aboard an Atlas V rocket on August 5, 2011, from Cape Canaveral Air Force Station, FL. And lastly, the GRAIL mission launched aboard a Delta II Heavy launch vehicle on September 10, 2011.	
	FY 2011 Performance Improvement Plan: NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective actions will be taken as needed.	

Additional Context

Performance Goal 5.4.1.1: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches is rated Green. On average NASA, achieves its success rate for expendable launches, and expects to remain on track for future planned ones.

Performance Measure ES-11-12: Complete the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) Mission Readiness Review is rated Green. This annual performance goal was met. The NPP Mission Readiness Review was completed on September 6, 2011.

Science Mission Objectives (Including Those Beyond Glory)		
Fiscal Year 2011 Performance Improvement	Performance Goal 2.1.5.2	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	HPPG: In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011.	FY 2011 Red
	Why Performance Goal 2.1.5.2 was Not Met: This high priority performance goal was not met, due to the loss of the Glory mission when the fairing from the Taurus XL launch vehicle failed to separate from the rocket. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission was successfully launched on October 28, 2011.	
	FY 2011 Performance Improvement Plan: NASA continues to take actions to mitigate any impacts from the Glory launch mishap. The Science Mission Directorate (SMD) is evaluating the loss of the mission on the long-term science objectives and discussing the options available to keep on-track toward this performance goal. The relative priority for replacing the Glory measurements will be considered in the context of the Earth Science portfolio and all of its objectives.	
Fiscal Year 2011 Performance Improvement	ES-11-13 (Performance Goal 2.1.5.2)	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Complete the Glory Launch Readiness Review.	FY 2011 Red
	Why Measure ES-11-13 was Not Met: The Glory Launch Readiness Review was completed on February 21, 2011, with a second review completed on March 2, 2011. The spacecraft and instruments were checked out and prepared to successfully begin their mission. However, the Glory mission, which was launched from Vandenberg Air Force Base on March 4, 2011, did not reach orbit, due to a mishap with the launch vehicle. Initial evidence suggests that the fairing, which protects the spacecraft during takeoff atop the Taurus XL launch vehicle, did not separate as required, when it reached the appropriate altitude.	
	FY 2011 Performance Improvement Plan: See the FY 2011 Performance Improvement Plan for Performance Goal 2.1.5.2 above.	

Commercial Space Flight Development

Throughout FY 2010, NASA's Commercial Orbital Transportation Services (COTS) partners, SpaceX and Orbital, continued to make progress toward developing systems to provide cargo resupply services to the International Space Station. Commercial development is a new way of doing business for NASA, and the partners continue to learn and make progress. As the partners have transitioned from development to integration and testing, they have encountered technical challenges similar to the development of any major space system. Subsequently, the resolution of these challenges has caused delays to the partners' demonstration flights into FY 2011.

In December 2010, SpaceX launched its first demonstration of its COTS transportation capabilities. Both SpaceX and Orbital are expected to demonstrate proximity operations and berthing to the International Space Station (ISS) in FY 2012 to complete the COTS milestones and prove maturity of the systems for ISS commercial resupply services. In FY 2011, NASA augmented funding of the COTS Space Act Agreements to add additional milestones for risk-mitigation, including a first-flight of Orbital's Taurus II launch vehicle in December 2011. NASA continues to work actively with its partners to ensure success of the COTS development through completion of demonstration flights and start of commercial resupply services to ISS in FY 2012.

The performance measures below demonstrate the technical challenges that are seen on the development of any major space system and how both NASA and its partners will continue to address these, to head toward success.

Fiscal Year 2010 Performance Improvement	Outcome 5.2	FY 2010 Yellow
	Accountable Organization: Exploration Systems Mission Directorate, Constellation Systems	
	By 2010, demonstrate one or more commercial space capabilities for ISS cargo and/or crew transport.	
	Why Outcome 5.2 was Not Met: Both partners, Space Exploration Technologies Corporation (SpaceX) and Orbital Sciences Corporation (Orbital), are making progress in demonstrating their respective transportation capabilities. The partners moved their initial demonstration flights to FY 2011 due to technical issues encountered during development efforts.	
	FY 2010 Performance Improvement Plan: SpaceX is planning for its first ISS demonstration flight in late fall 2010, with remaining flights scheduled for later in FY 2011. Orbital currently is planning its demonstration flight for fall 2011.	
Fiscal Year 2010 Performance Improvement	Plan Update: NASA Commercial Orbital Transportation Services (COTS) partner SpaceX successfully completed their Demonstration 1 mission on December 8, 2010.	FY 2010 Yellow
	10CS07	
	Accountable Organization: Exploration Systems Mission Directorate, Constellation Systems	
	In FY 2010, have at least one partner demonstrate flight proximity operations with ISS.	
	Why Measure 10CS07 was Not Met: Both partners, SpaceX and Orbital, made progress in demonstrating their respective transportation capabilities. The partners moved their initial demonstration flights to FY 2011 due to technical issues encountered during development efforts and are continuing toward demonstrating flight operations with ISS in FY 2011.	
Fiscal Year 2010 Performance Improvement	FY 2010 Performance Improvement Plan: The second SpaceX flight, in June 2011, will demonstrate flight proximity operations with ISS. Orbital currently anticipates scheduling its demonstration flight for FY 2012.	FY 2010 Yellow
	Plan Update: APG 10CS07 was not completed in FY 2011 due to development challenges. Partner experienced delays as their program transitioned from design to integration and test; however, they continue to make technical progress toward their development and demonstration milestones. These challenges continue to be resolved, and NASA continues to work with our partners.	

Fiscal Year 2010 Performance Improvement	10CS08	FY 2010 Yellow
	Accountable Organization: Exploration Systems Mission Directorate, Constellation Systems	
	By the end of FY 2010, conduct one or more demonstration flights to, and berth with, the ISS.	
	Why Measure 10CS08 was Not Met: Both partners, SpaceX and Orbital, made progress in demonstrating their respective transportation capabilities. The partners moved their initial demonstration flights to FY 2011 due to technical issues encountered during development efforts and are continuing toward demonstration flights to, and berthing with, ISS in FY 2011.	
	FY 2010 Performance Improvement Plan: SpaceX is planning for its third demonstration flight to, and berth with, ISS in late FY 2011. Orbital currently anticipates scheduling its demonstration flight for FY 2012.	
Fiscal Year 2011 Performance Improvement	CS-11-2 (Performance Goal 1.2.1.1)	FY 2011 Yellow
	Accountable Organization: Human Exploration and Operations, Commercial Spaceflight	
	Conduct a minimum of one commercial cargo demonstration flight of proximity operations with ISS.	
	Why Measure CS-11-2 was Not Met: This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones.	
	FY 2011 Performance Improvement Plan: SpaceX and Orbital continue to make progress, mitigating risk and solving technical challenges, and plan a demonstration of proximity operations with ISS in FY 2012. During FY 2011, NASA negotiated additional risk mitigation milestones with each partner. The additional milestones help to improve mission success by (1) augmenting ground and flight testing; (2) accelerating development of enhanced cargo capabilities; or (3) further developing ground infrastructure needed for commercial cargo capabilities.	
Fiscal Year 2011 Performance Improvement	CS-11-3 (Performance Goal 1.2.1.1)	FY 2011 Yellow
	Accountable Organization: Human Exploration and Operations, Commercial Spaceflight	
	Conduct a minimum of one safe berthing of commercial cargo transportation systems with the ISS.	
	Why Measure CS-11-3 was Not Met: This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones.	
	FY 2011 Performance Improvement Plan: SpaceX and Orbital continue to make progress and plan to conduct a minimum of one safe berthing of commercial cargo transportation systems with the ISS in FY 2012. During FY 2011, NASA negotiated additional risk mitigation milestones with each partner to help improve mission success.	

Additional Context

Performance Measure CS-11-1: *Conduct a minimum of one commercial cargo demonstration flight of new cargo transportation systems* is rated Green. NASA's Commercial Orbital Transportation Services (COTS) partner SpaceX successfully completed its Demonstration 1 mission on December 8, 2010. Further details can be seen at http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-327_SpaceX_Launch.html.

Human Spaceflight Program Transition

On July 8, 2011, NASA launched the Space Shuttle *Atlantis* (STS-135) as the last mission of the Space Shuttle Program. With the addition of STS-135 to the Space Shuttle launch manifest, the program was extended six months past the target date of retiring the Shuttle by the end of 2010. The delay of the original retirement date caused downrange effects on the transition of hardware, assets, and workforce to new human spaceflight programs.

With the landing of *Atlantis*, NASA was able to begin transition and closeout of the Space Shuttle Program and proceed with the new direction of the Nation's new beyond low-Earth orbit exploration program. In FY 2011, NASA began developing plans for implementing the Space Launch System (SLS) and Multi-Purpose Crew Vehicle (MPCV) projects, including transition of relevant design and developmental activities of the Constellation Program. In September 2011, NASA announced the selection of the new SLS and MPCV designs and is moving forward with transition of applicable work from the Ares and Orion projects toward a first light of the 70-ton SLS vehicle in 2017.

The performance ratings in the table below demonstrate the combined delay of the Space Shuttle Program and the transition to the new programs, with their requisite start-up activities. NASA will strive to meet the goals set forth for MPCV and SLS in the coming years.

ISS Assembly & Space Shuttle Retirement			
Fiscal Year 2010 Performance Improvement	Outcome 1.2		
	Accountable Organization: Space Operations Mission Directorate, Space Shuttle Program		
	By December 31, 2010, retire the Space Shuttle.		FY 2010 Yellow
	Why Outcome 1.2 was Not Met: The rating for 1.2 reflects an adjusted mission schedule that postpones Shuttle retirement activities in response to an Administration policy decision to extend Shuttle flights beyond 2010 to support the completion of the International Space Station.		
	FY 2010 Performance Improvement Plan: Based on the extended mission schedule, NASA plans to retire the Space Shuttle in 2011.		
Plan Update: NASA completed the Space Shuttle manifest with the launch and landing of STS-135 in July 2011. NASA is executing the plans to display the four remaining orbiters—three operational orbiters and the program's test vehicle—at institutions across the country to inspire the next generation of explorers and engineers.			
Fiscal Year 2010 Performance Improvement	10ISS03		
	Accountable Organization: Space Operations Mission Directorate, International Space Station Program		
	Per the final configuration agreed to by the International Partners, fly the ISS elements and logistics baselined for FY 2010.		FY 2010 Yellow
	Why Measure 10ISS03 was Not Met: Due to technical difficulties and unforeseen delays, NASA was unable to fly all ISS elements and logistics planned for FY 2010.		
	FY 2011 Performance Improvement Plan: Consistent with an Administration policy decision, NASA has revised the Shuttle manifest and related logistics to accommodate the delays experienced in FY 2010 and anticipates ISS completion in FY 2011.		
Plan Update: The Space Shuttle delivered the final elements of the ISS configuration in FY 2011.			

Transitioning Shuttle Assets and Workforce to New Programs		
Fiscal Year 2010 Performance Improvement	10SSP03	FY 2010 Yellow
	Accountable Organization: Space Operations Mission Directorate, Space Shuttle Program	
	Complete close-out and transfer plans for all remaining Space Shuttle flight hardware elements and other major Space Shuttle property assets, including the disposition plans for the Orbiters and the means by which significant gaps in human spaceflight operations capabilities will be managed if needed to support future activities.	
	Why Measure 10SSP03 was Not Met: The Agency's decision to extend Space Shuttle flights into 2011 and the uncertainty regarding the future of the Constellation Program caused a delay in finalizing Shuttle asset disposition plans and resolving the human space flight gap.	
	FY 2010 Performance Improvement Plan: Disposition plans for the orbiters will be completed once NASA announces final display locations. NASA plans to resolve funding gaps for human spaceflight capabilities through the FY 2012 budget development process.	
Fiscal Year 2010 Performance Improvement	10SSP05	FY 2010 Yellow
	Accountable Organization: Space Operations Mission Directorate, Space Shuttle Program	
	With the Constellation Program, complete and deliver one workforce transition strategy report update to Congress in FY 2010.	
	Why Measure 10SSP05 was Not Met: Development of Workforce Transition Strategy reports has been rescheduled pending direction to the Agency following the release of the FY 2011 President's Budget Submit, the proposed transition of the Constellation Program, and identification of future work. In the FY 2011 budget process, the President proposed to Congress that the Constellation Program be transitioned and NASA adjusted its spending on the program consistent with its budget request and with the Appropriation provided by Congress for FY 2010.	
	FY 2010 Performance Improvement Plan: The plan is pending decision of the proposed transition of the Constellation Program.	
Fiscal Year 2011 Performance Improvement	AMO-11-1 (Performance Goal 5.1.1.1)	FY 2011 Yellow
	Accountable Organization: Mission Support Directorate, Office of Human Capital Management	
	Seventy-five percent or more of Shuttle workforce has been realigned for new Agency needs.	
	Why Measure AMO-11-1 was Not Met: NASA did not meet the target for this annual performance goal as a result of Congressional budget action. The addition of a Shuttle mission and delays in the mission manifest resulted in a slower than planned transition of workforce from the Space Shuttle Program. Additionally, the year-long Continuing Resolution significantly delayed the start of new programs to which NASA planned to transition the Space Shuttle workforce.	
	FY 2011 Performance Improvement Plan: Upon landing of the Space Shuttle <i>Atlantis</i> on STS-135 to complete the shuttle program in July 2011, the NASA civil service workforce is being realigned with other Agency priorities. NASA plans to complete this activity in FY 2012.	

Formulation of New Human Space Exploration Programs		
Fiscal Year 2010 Performance Improvement	10SFS09	
	Accountable Organization: Space Operations Mission Directorate, Rocket Propulsion Test Program	
	Identify agency rocket propulsion test core capabilities (both infrastructure and critical skills) and maintain them at appropriate levels to be able to meet NASA's current and future rocket testing requirements, and deliver an integrated Agency-level Rocket Propulsion Test Plan that spans the next 10 years and includes DoD and commercial partner requirements and capabilities, as appropriate.	
	Why Measure 10SFS09 was Not Met: The Agency-level Rocket Propulsion Test Plan due date was re-negotiated and agreed upon between NASA and the Office of Management and Budget. The new due date is December 31, 2010.	FY 2010 Yellow
	FY 2010 Performance Improvement Plan: The Rocket Propulsion Test Plan is on schedule to meet the December 31, 2010, deadline.	
	Plan Update: The draft Rocket Propulsion Test (RPT) Master Plan was delivered to Headquarters in February 2011. The RPT Master Plan was initially drafted with Constellation Program requirements and had to be revised for the new programs. Due to a delay in identification and incorporation of firm test requirements for the follow-on Space Launch System (SLS), final approval of the Master Plan was not finalized until July 2011. The Rocket Propulsion Test Plan was delivered to Headquarters and signed by the Associate Administrator of the Space Operations Mission Directorate on July 11, 2011.	
Fiscal Year 2011 Performance Improvement	SFS-11-4 (Performance Goal 5.4.2.1)	
	Accountable Organization: Human Exploration Operations Mission Directorate, 21st Century Ground Systems Program	
	Develop a 21st Century Space Launch Complex (21st CSLC) plan.	
	Why Measure SFS-11-4 was Not Met: This annual performance goal was not met due to a revision on the originally planned schedule for this activity. As is typical with NASA programs and projects in the formulation phase, schedules are expected to change as they are refined heading toward the development phase. As the fiscal year progressed, the maturity of the Human Exploration Capabilities programs increased, and NASA began to work through the significant milestones and associated product development and has settled on the current schedule. Under this schedule, NASA expects that this activity will be completed in the first quarter of FY 2012.	FY 2010 Yellow
	FY 2011 Performance Improvement Plan: The 21st Century Ground Systems Program (21CGS) was formally stood up in FY 2011 in accordance with NASA's authorization from Congress, and continues to make progress toward developing its plans to support Exploration Systems Development. Although the 21CGS plan is not officially required until the completion of the Systems Design Review, the draft plan is in the review cycle, with an expected approval in FY 2012.	

Additional Context

Performance Goal 1.1.1.2: *HPPG: Safely fly out the Space Shuttle manifest and retire the fleet* is rated Green. This goal achieved all of its FY 2011 targets.

Performance Measure SSP-11-1: *Release major Space Shuttle operations facilities at Kennedy Space Center for future institutional and programmatic use.* This goal has been met.

Performance Goal 5.3.1.1: *Develop and execute the Rocket Propulsion Test (RPT) Master Plan* is rated Green.

Performance Measure SFS-11-1: *Release the Rocket Propulsion Test (RPT) Master Plan* is rated Green. This annual performance goal was met. The Rocket Propulsion Testing Master Plan was signed in July 2011. The plan will be reviewed annually and adjusted according to any evolving requirements and funding availability.

Performance Goal 1.3.1.1: *Complete design reviews for Space Launch System (SLS)* is rated Green. New human space flight programs were initiated in fiscal year 2011.

Performance Measure HEC-11-1: *Develop top level Agency requirements and draft Program Plan for Space Launch System (SLS)* is rated Green.

Performance Goal 1.3.1.2: *Complete design reviews for Multi-Purpose Crew Vehicle (MPCV)* is rated Green.

Performance Measure HEC-11-2: *Develop top level Agency requirements and Program Plan for Multi-Purpose Crew Vehicle (MPCV)* is rated Green.

Performance Goal 5.4.2.1: *By FY 2014, enable future government and commercial launching and testing from the Florida launch and range complex* is rated Green. Despite delays due to the year long continuing resolution, the top-level requirements were defined and baselined in the Human Exploration Capabilities Requirements Document during 2011, and a draft program plan is in review.

Scientific Research and Technology Development Process

Scientific research and technology development is an ongoing and fluid business. Often goals are not met because of the dynamic nature of research and technology, which could be impacted by new discoveries, refinement to plans based on new knowledge, new partnerships, a change in priorities, or an optimistic estimate of the pace of future progress into the unknown. The process of creating science or technology generally starts with setting science or research objectives and then finding the “best” performer to contribute toward reaching these objectives, through awarded intramural or extramural efforts. Once awarded, science or research activities begin, and then culminate with a transfer of knowledge or technology placed into an application. Multiple factors can slow the award process, delivery of the scientific or research product, and/or the transition of scientific knowledge or technology for application. For example, delays in the selection process may be caused by delayed availability of funds or a refinement to the solicitation for new ideas, based on a decision to factor new cutting-edge knowledge into the objectives. Additionally, delivery of scientific or research products on original timeframes can be impacted by the availability of a research platform or the discovery that attaining the objectives is unexpectedly complex. NASA’s science and research products often depend on vehicle availability for space flight or complex ground-based laboratories, such as a wind tunnel, or the availability of appropriately skilled researchers. Transition of science or technology into an application, can also be impacted by factors in these processes, as well.

NASA’s performance measures demonstrated in the table below reflect these various factors and their impact on the planned scientific research and technology development and how the Agency will attempt to mitigate these factors in the coming fiscal year.

Times to Award Can Be Impacted by Various Factors			
Fiscal Year 2010 Performance Improvement	Outcome 3E.5		
	Accountable Organization: Aeronautics Research Mission Directorate		
	For vehicle and propulsion technologies that simultaneously reduce fuel burn, noise, and emissions, by 2016 develop a well-informed trade space, document performance potential, and identify technical risks to a level that enables incorporation of technologies into the design of new aircraft.		FY 2010 Yellow
	Why Outcome 3E.5 was Not Met: In addition conducting research through test flights of a hybrid wing body aircraft configuration, NASA sought out additional advanced vehicle concepts from its stakeholders through a solicitation. NASA significantly re-scoped the effort for the NASA Research Announcement (NRA) mid-year, changing the requirements from an advanced vehicle concept study NRA to an advanced vehicle concept study that will develop two concepts to the Preliminary Design Review (PDR) stage.		
	FY 2010 Performance Improvement Plan: NASA is currently negotiating these contracts and expects to announce awards in the first quarter of FY 2011.		
Plan Update: Three awards were made in the first quarter of FY 2011. Two awards in November 2010, and one in December 2010. This Outcome is (was) back on track to achieve 2016 goals. Note that this Outcome has been revised in both the 2011 Strategic Plan and the FY 2011 Performance Plan.			
Fiscal Year 2010 Performance Improvement	10AT12		
	Accountable Organization: Aeronautics Research Mission Directorate		
	In FY 2010, award a contract to conduct N+2 vehicle systems studies.		FY 2010 Yellow
	Why Measure 10AT12 was Not Met: NASA significantly rescoped the effort for the NRA mid-year, changing the requirements from an advanced vehicle concept study NRA to an advanced vehicle concept study that will mature two concepts to PDR stage.		
	FY 2010 Performance Improvement Plan: NASA is currently negotiating these contracts and expects to announce awards in the first quarter of FY 2011.		
Plan Update: Three awards were made in the first quarter of FY 2011. Two awards in November 2010 and one in December 2010. This work has been accomplished.			

Fiscal Year 2010 Performance Improvement	10ES20	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 227 days.	FY 2010 Yellow
	Why Measure 10ES20 was Not Met: The time within which 80 percent of the Earth Science selection notifications were made decreased in FY 2010 to 231 days, but fell just short of the ultimate goal of 227 days, which it was scheduled to achieve this fiscal year.	
	FY 2010 Performance Improvement Plan: The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. These include the scheduling of proposal due dates to spread out the work for the understaffed research program managers and providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority.	
	Plan Update: With the impact of the FY 2011 Continuing Resolution (CR) taken into account, Earth Science showed improvement during FY 2011 by decreasing the time for selection notifications from 231 days to less than 200. (value removes the estimated impact of the extended CR).	
Fiscal Year 2010 Performance Improvement	10HE12	
	Accountable Organization: Science Mission Directorate, Heliophysics Division	
	Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days.	FY 2010 Red
	Why Measure 10HE12 was Not Met: The time within which 80 percent of Heliophysics selection notifications were made increased in FY 2010 to 235 days, exceeding the goal of 215 days.	
	FY 2010 Performance Improvement Plan: The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. These include the scheduling of proposal due dates to spread out the work for the understaffed research program managers and providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority.	
	Plan Update: The Heliophysics Division took the steps noted above, and decreased the time within which 80 percent of selection notifications were made to 188 days in FY 2011, surpassing the goal of 207 days.	
Fiscal Year 2010 Performance Improvement	10PS14	
	Accountable Organization: Science Mission Directorate, Planetary Science Division	
	Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days.	FY 2010 Red
	Why Measure 10PS14 was Not Met: The time within which 80 percent of Planetary Science selection notifications were made increased in FY 2010 to 243 days, exceeding the goal of 221 days.	
	FY 2010 Performance Improvement Plan: The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. These include the scheduling of proposal due dates to spread out the work for the understaffed research program managers and providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority.	
	Plan Update: With the impact of the FY 2011 Continuing Resolution (CR) taken into account, Planetary Science showed only minimal improvement during FY 2011, decreasing the time for selection notifications from 243 days to approximately 240 days (value removes the estimated impact of the extended CR).	
Fiscal Year 2011 Performance Improvement	ES-11-22 (Efficiency Measure)	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Reduce time within which 80 percent of NASA Research Announcement (NRA) research grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.	FY 2011 Yellow
	Why Measure ES-11-22 was Not Met: This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Earth Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 33 days, approximately 16% of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate.	
	FY 2011 Performance Improvement Plan: The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. In FY 2012, this will include providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. As the year progresses, other options will also be visited.	

Fiscal Year 2011 Performance Improvement	PS-11-17 (Efficiency Measure)		
	Accountable Organization: Science Mission Directorate, Planetary Science Division		
	Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.		
	Why Measure PS-11-17 was Not Met: This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Planetary Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 76 days, approximately 35% of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. It is estimated that without the impact of the Continuing Resolution, the Planetary Science Division would have missed its target regardless. Other factors contributing to the missed target included staffing transitions in positions key to this process during FY 2011 (new Research and Analysis Lead and new program scientists). The involvement of these scientists in critical mission activities for multiple 2011 launches (Juno, GRAIL, MSL), as well as multiple FY 2011 Announcements of Opportunity also prevented improvement.		
	FY 2011 Performance Improvement Plan: Many of the staffing-level factors seen in FY 2011, that contributed to missing the target, are not expected to be repeated and impact the FY 2012 results. The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. In FY 2012, this will include providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. As the year progresses, other options will also be visited.		FY 2011 Red
Change Due to New Findings			
Fiscal Year 2010 Performance Improvement	10AT02		
	Accountable Organization: Aeronautics Research Mission Directorate		
	Develop an atomistically-based model capable of predicting within 25% the degradation caused by environmental effects on interfaces in selected polymer matrix composite materials.		
	Why Measure 10AT02 was Not Met: This effort attempted to significantly push the state-of-the-art in atomistic-based computational modeling, and application of such models to predict the effects of aging of epoxy matrix resins used on commercial aircraft. The computational model that was developed predicted a reduction in surface energy over time, which is consistent with physical aging phenomenon reported in the literature. While the surface energy predictions differed somewhat from the measured values, experiments on lap shear specimen data for both surface energy and lap shear strength validated the predicted trends. Due to variability in computational and experimental results, it was not possible to validate the computational model for accurate quantitative prediction of physical aging to the performance level defined in the green success criteria.		
	FY 2010 Performance Improvement Plan: The activity as defined in the APG is complete. The performance level defined in the yellow success criteria was achieved. Since this was a “stretch-goal” no plans exist to continue to attempt to reach the absolute accuracy reflecting a green success criteria. However, the results obtained will inform future research in atomistic computational modeling. Further, successful prediction of the trends observed in experiments show that atomistic computational modeling may indeed be a valuable tool to guide new material development for improved durability.		FY 2010 Yellow
	Plan Update: No further activity is planned.		
Availability of Research Facilities			
Fiscal Year 2010 Performance Improvement	10AC12		
	Accountable Organization: Exploration Systems Mission Directorate, Advanced Capabilities		
	Demonstrate one year of experimental operation of the Vehicle Cabin Atmosphere Monitoring (VCAM) system on orbit.		
	Why Measure 10AC12 was Not Met: NASA delivered and installed the VCAM in FY 2010. To date, the instrument has operated successfully; however, due to delays in the Space Shuttle launch schedule this instrument was not in place in time to demonstrate a full year of operation by the close of the fiscal year, per the annual performance goal.		
	FY 2010 Performance Improvement Plan: The VCAM is fully functional and on track for reaching one year of experimental operation in March 2011.		FY 2010 Yellow
	Plan Update: In May 2011, the VCAM successfully completed one year of operations onboard the ISS. An independent assessment of the VCAM's performance validated its technical capabilities.		

Fiscal Year 2010 Performance Improvement	10AT10	
	Accountable Organization: Aeronautics Research Mission Directorate	
	Complete CFD predictions of ramjet-to-scramjet mode-transition and compare to wind tunnel and/or X-51 flight test data.	FY 2010 Yellow
	Why Measure 10AT10 was Not Met: NASA delayed this work into FY11 due to Air Force X-51 flight delays. NASA received the data from the first flight on May 26, 2010, in August 2010. The next flight (second of four) is scheduled for the December 2010 through January 2011 time period. The data from the remaining X-51 flights is required to meet APG. The APG completion date estimate has been revised to September 2011.	
	FY 2010 Performance Improvement Plan: Information from remaining flights of Air Force X-51 required to achieve this APG.	
Plan Update: Information from the remaining flights of Air Force X-51 are required to achieve this APG. The second flight of the X-51A was attempted June 13, 2011. However, the flight test failed due to the failure of scramjet to operate. The X-51 test flight team is continuing to review the flight data to determine the cause of the failure. As such, the schedules for X-51 flights 3 and 4 are unknown at this time. NASA will conduct the CFD comparisons with the flight test data and achieve this annual performance goal, once all data has been received from successful flight tests of the X-51A.		
Fiscal Year 2011 Performance Improvement	AR-11-9 (Performance Goal 4.1.3.1)	
	Accountable Organization: Aeronautics Research Mission Directorate	
	Validate NASA propulsion Computational Fluid Dynamics (CFD) codes using Hypersonic International Flight Research Experimentation (HIFiRE) scramjet flight data and ground-based test results.	FY 2011 Yellow
	Why Measure AR-11-9 was Not Met: This annual performance goal was not met, in this fiscal year, and is expected to be accomplished in the June/July 2012 timeframe. To validate the Computational Fluid Dynamics (CFD) code, NASA is gathering this data on the Hypersonic International Flight Research Experimentation (HIFiRE) #2 vehicle's scramjet, while in flight. The Air Force has moved the date for the HIFiRE #2 vehicle launch until Summer 2012.	
FY 2011 Performance Improvement Plan: This goal will be considered complete once code validation occurs using the flight data when available, following the successful launch of the HIFiRE #2.		
Fiscal Year 2011 Performance Improvement	AR-11-12 (Efficiency Measure)	
	Accountable Organization: Aeronautics Research Mission Directorate	
	Deliver at least 86 percent of on-time availability for operations and research facilities.	FY 2011 Yellow
	Why Measure AR-11-12 was Not Met: The on-time availability of the operations and research facilities managed by the Aeronautics Test Program, was 80%, slightly less than the targeted 86% availability. NASA did not meet its target, primarily due to the downtime, introduced with the failure of subsystems in two facilities at the Glenn and Langley Research Centers. At Glenn Research Center, the 8 foot by 6 foot Wind Tunnel, had unscheduled downtime to repair the Open Rotor Propulsion Rig (ORPR) forward balance, which has resulted in rescheduling testing into FY 2012. At Langley Research Center, the 14 foot by 22 foot Wind Tunnel experienced unscheduled downtime due to issues with the main drive lubrication system and the motor generator set.	
	FY 2011 Performance Improvement Plan: In FY 2011, the Aeronautics Test Program (ATP) Capability Investment project manager initiated a new set of facility assessment actions which will provide the program with updated information on the condition of the tunnel infrastructure and sub-systems. To date, five assessments have been completed and six additional assessments are scheduled to begin at the end of this fiscal year. The updated condition information will potentially allow the ATP program to identify and resolve critical maintenance issues before they impact customer testing schedules.	

Additional Context

Performance Measure HE-11-9: *Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days* is rated Green. This annual performance goal was met. The Heliophysics Division within the Science Mission Directorate has met its annual target for time to complete its grant proposal evaluation and selection process.

Performance Measure AS-11-9: *Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days* is rated Green. This annual performance goal was met. The Astrophysics Division within the Science Mission Directorate has met its annual target for time to complete its grant proposal evaluation and selection process.

Baseline Cost and Schedule Changes

NASA's projects are generally high-risk, one-of-a-kind space flight mission developments that usually do not enter an "operational" or production state. Estimating cost and schedule baselines for these types of projects is complex and challenging, with many factors that introduce risk and must be accounted for. Risks can be introduced based on factors in the industrial base such as launch vehicle availability, an absence of needed vendor capabilities, and/or counterfeit parts. An instability of funding, delays in funding, or a misalignment of resources, which is estimated to be needed in a specified timeframe, can significantly contribute to cost and schedule growth. Additionally, various acquisition challenges, such as protests on a vendor award, can impact project costs and schedule baselines. Ineffective project planning and controls can impact the ability to understand these factors and to address them in a manner to either recognize or mitigate cost and schedule growth. Specifically, effective lifecycle cost and schedule management requires:

- Good lifecycle cost-estimating policy and processes (sets good baselines).
- Institution of tracking and trending methodologies and using "best practice" tools to predict life-cycle estimate changes (proactively predicts baseline drift and violation of that baseline).
- Effective risk identification, and planning for the costs to mitigate and deal with these risks if they manifest (manages threats to life-cycle cost/schedule changes).
- Clear reporting requirements and responsibilities (ensures accountability).
- Making budget planning and allocation decisions based on lifecycle cost and schedule estimates and the performance toward these (ensures alignment of funding needs to lifecycle needs).

Since 2005, the Agency has taken many steps to make progress in this complex area, including new estimating processes, setting new policies to better align budgeting with cost estimation, and reports on both a quarterly and annual basis to the Office of Management and Budget and U.S. Congress, respectively, ensuring accountability and transparency. NASA continues to build on each step toward improving cost and schedule performance.

NASA began a new cost and schedule estimation initiative, joint cost and schedule confidence levels (JCL), to increase the likelihood of project success at the specified funding level. The application of the JCL process is expected to increase the insight of project and program managers and others into uncertainties and contingencies within an integrated cost and schedule plan. NASA is taking steps in the early (formulation) stages of projects to ensure appropriate technical risk reduction and is actively refining the cost ranges for projects in formulation to improve budget estimates as these projects make their way through Phases A and B. Projects in development are budgeted to a Life Cycle Cost reflecting a 70 percent cost confidence level (CCL) or, more conservatively, a JCL. In conjunction with the JCL initiative, NASA issued an Interim Directive to the *NASA Procedural Requirements 7120.5D: Space Flight Program and Project Management Requirements*. This interim directive strengthened and clarified the existing program and project management requirements regarding cost and schedule baselining and rebaselining policy.

NASA enhanced acquisition policies and procedures. One main policy element introduced was to base acquisition on an expanded view of cost and schedule risks realistic cost estimates and achievable schedules, and to confirm this on an annual basis. This includes incorporating a risk-informed acquisition process that provides an integrated and holistic view of risk, including Agency-level, institutional, and program/project. A more holistic view of risk helps to better match the stakeholder expectations and the "true" resources required to address the risks and achieve those expectations. An integrated perspective of risks and aids for analyzing competing decision alternatives can help appropriately apply funds.

NASA also increased its oversight and surveillance, on programs and projects as well as procurements. The construct for performance reviews was modified to ensure that at key decision points, in-depth independent reviews were conducted, paired with ongoing surveillance in between. Programs and projects are both subjected to episodic independent reviews, conducted by Standing Review Boards, at key points in the life cycle. Monthly or quarterly senior management reviews will assess ongoing programmatic and institutional performance and identify crosscutting issues. To aid in both program/project and contractor surveillance and oversight, Agency earned value management (EVM) capabilities and capacity are being increased. NASA decided to build an Agency-wide capability to effectively use EVM on in-house efforts and to provide an integrated contractor and in-house EVM reporting capability. The latter process is expected to be rolled out initially on the Ice, Clouds, and Land Elevation Satellite (ICESat)-II and Space Launch System projects.

NASA will continue to follow through with the new policies, procedures, and management attention on cost and schedule growth in the coming year, with the goal of improving the Agency's future performance.

Fiscal Year 2010 Performance Improvement	10IT11	FY 2010 Red
	Accountable Organization: Office of the Chief Information Officer	
	Complete all development projects within 110% of the cost and schedule baseline.	
	Why Measure 10IT11 was Not Met: All but one project finished within the required 110 percent of cost and schedule baselines. The Security Operations Center (SOC) implementation (Phase-2) project has undergone schedule slips, due to delays in facilities power modifications resulting in delays of receiving IT Security event data from numerous sources across the Agency. The delay in having adequate power to the facility kept the SOC from being able to capture data, thereby not allowing testing and not being ready to complete the ORR. The extra power lines and resultant coordination were not planned for when the project was initially scoped and were beyond the initial project plan estimates. The final SOC implementation plan will increase cost to 145 percent and schedule to 161 percent of the initial project scope. NASA reviewed this project during implementation, and given the importance of IT security, approved additional time and funding for the project.	
	FY 2010 Performance Improvement Plan: There are no options to achieving this goal. NASA determined the IT Security Operations Center project implementation fits into the CyberSecurity scope and needed to be accomplished to protect NASA's IT vulnerability.	
	Plan Update: N/A	
Fiscal Year 2010 Performance Improvement	10HE09	FY 2010 Red
	Accountable Organization: Science Mission Directorate, Heliophysics Division	
	Complete all development projects within 110% of the cost and schedule baseline.	
	Why Measure 10HE09 was Not Met: NASA did not complete the Solar Dynamics Observatory (SDO) within 110 percent of cost and schedule baselines. SDO initially slipped from its 2008 firm slot in the launch manifest due to late delivery of avionics boxes and instruments and problems with electronics parts and the high-speed data bus. SDO then experienced difficulty obtaining a new slot in the launch manifest, as no firm slots were available until 2010 due to multiple Atlas V launch vehicle issues and associated launch queue delays.	
	FY 2010 Performance Improvement Plan: NASA launched SDO in February 2010. This exceeded the original schedule by 48 percent, but the mission's lifecycle cost remains within seven percent of the original cost baseline.	
	Plan Update: N/A	
Fiscal Year 2010 Performance Improvement	10ES17	FY 2010 Red
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Complete all development projects within 110% of the cost and schedule baseline.	
	Why Measure 10ES17 was Not Met: NASA did not complete the Glory and Aquarius missions within 10 percent of their cost and schedule baselines.	
	FY 2010 Performance Improvement Plan: The Glory mission experienced significant cost and schedule growth due primarily to the failure of the Orbiting Carbon Observatory (OCO) Taurus XL launch vehicle and issues with the vendor's production of acceptable boards for the Maxwell Single Board Computers. Glory's current projected lifecycle cost is 68 percent higher than the baseline established at Confirmation Review. The mission is tentatively scheduled for a February 2011 launch readiness date, a 72 percent increase in schedule. The Aquarius launch readiness date has been rescheduled for April 2011 due to delays in the development of the international partner's Mission Operations System. The schedule for the mission has increased by 60 percent, but the lifecycle cost remains within 15 percent of the baseline.	
	Plan Update: N/A	
Fiscal Year 2011 Performance Improvement	ES-11-19 (Efficiency Measure)	FY 2011 Red
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Complete all development projects within 110 percent of the cost and schedule baseline.	
	Why Measure ES-11-19 was Not Met: This annual performance goal was not met, due to cost and schedule growth that exceeded 10 percent of their estimated baseline for the NPOESS Preparatory Project (NPP), Glory, and Aquarius missions. The NPP mission experienced delays due to the restructure of the project management and on-going development issues with an instrument, contributed by one of NASA's partners. The Aquarius mission was delayed by NASA's international partner, after the successful delivery of NASA's instrument contribution. The Glory mission had both instrument and spacecraft technical issues, across its development.	
	FY 2011 Performance Improvement Plan: NASA's new 70 percent CL requirements include consideration of the risks of partnership. These and other procedures subsequently put in place are improving cost and schedule performance.	

Development Partner Challenges			
Fiscal Year 2010 Performance Improvement	10ES02		
	Accountable Organization: Science Mission Directorate, Earth Science Division		
	Develop missions in support of this Outcome, as demonstrated by completing Aquarius Operational Readiness Review (ORR).		FY 2010 Yellow
	Why Measure 10ES02 was Not Met: Due to delays in the development of the international partner's Mission Operations System, the ORR was not completed in FY 2010.		
	FY 2011 Performance Improvement Plan: A specific date has not been identified, but NASA estimates this to be in early 2011. However, any delays to the overall mission schedule could cause the ORR to move further.		
Plan Update: The Aquarius Operational Readiness Review was completed April 28, 2011.			
Vendor Quality Parts and Processes			
Fiscal Year 2010 Performance Improvement	10ES21		
	Accountable Organization: Science Mission Directorate, Earth Science Division		
	Develop missions in support of this Outcome, as demonstrated by completing the Pre-Ship Comprehensive Performance Test for Glory.		FY 2010 Yellow
	Why Measure 10ES21 was Not Met: The Glory Pre-Ship Comprehensive Performance Test began on September 17, 2010, but was not completed until October 4, 2010. The test was delayed primarily due to resolution of spacecraft hardware anomalies.		
FY 2010 Performance Improvement Plan: The test was completed successfully on October 4, 2010.			
Fiscal Year 2010 Performance Improvement	10AS07		
	Accountable Organization: Science Mission Directorate, Astrophysics Division		
	Develop missions in support of this Outcome, as demonstrated by completing the first competed Early Science observations on the Stratospheric Observatory for Infrared Astronomy (SOFIA).		FY 2010 Yellow
	Why Measure 10AS07 was Not Met: Technical problems with the telescope cavity door actuator on the SOFIA aircraft, due to quality control issues at the vendor of the actuator, led to increased time required for flight testing and certification for open-door flight at the altitude required for Early Science. NASA worked directly with the vendor to address and resolve the quality control issues.		
	FY 2010 Performance Improvement Plan: Flight testing of the full flight envelope has been completed, and the first image has been acquired by the telescope in flight. The program is currently on track for the first Early Science observation by December 2010.		
Plan Update: SOFIA completed the first of three science flights on Wednesday, December 1, 2010.			
Fiscal Year 2011 Performance Improvement	ES-11-3 (Performance Goal 2.1.1.2)		
	Accountable Organization: Science Mission Directorate, Earth Science Division		
	Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing.		FY 2011 Yellow
	Why Measure ES-11-3 was Not Met: The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays.		
FY 2011 Performance Improvement Plan: To address the coating adhesion issue, a decision was made to proceed with an alternate vendor and process (black anodizing) for the parts. The change was implemented and all parts now meet specification. Additionally, the optical path misalignment issue was addressed and appears to be resolved, but it will remain open until confirmed during instrument-level vibration testing (scheduled for December 2011). These two issues have resulted in an approximately a one month delay in delivery of the instrument (now April 2012). This delay is not expected to impact the overall delivery schedule of the observatory or the launch readiness date (LRD). The Spacecraft System-Level Testing has been scheduled for December 2011 due to the late subsystem vendor deliveries. However, the spacecraft remains on plan to be delivered in March 2012, with no impact to the Launch Readiness Review.			

Fiscal Year 2011 Performance Improvement	ES-11-6 (Performance Goal 2.1.2.2)	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Complete the Global Precipitation Mission (GPM) Systems Integration Review	FY 2011 Yellow
	Why Measure ES-11-6 was Not Met: Both the NASA spacecraft and instrument developments are experiencing challenges in subsystem deliveries. These development challenges are resulting from various issues including defects discovered in flight parts, component manufacturing throughput issues and workmanship issues at supply vendors. In addition, the delivery of the JAXA (Japanese space agency)-provided Dual Precipitation Radar (DPR) instrument has been delayed due to disruptions at, and damage to, the test facility resulting from the March 2011 earthquake. Technical issues with the DPR were also identified during environmental testing. It is currently estimated that these challenges will result in a launch readiness delay of eleven months, from July 2013 to June 2014.	
	FY 2011 Performance Improvement Plan: NASA and JAXA are working together to replan the program to accommodate these delays. NASA and JAXA have taken actions that include implementing extended shifts/weekend work and integration and testing workarounds (for NASA, the use of engineering test units in place of flight subsystems) to recover schedule where feasible. Completion of the Systems Integration Review is scheduled for the second quarter of FY 2012.	

Launch Vehicle Availability & Reliability/Manifest Issues		
Fiscal Year 2010 Performance Improvement	10ES10	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Develop missions in support of this Outcome, as demonstrated by completing the SMAP Preliminary Design Review (PDR).	FY 2010 Yellow
	Why Measure 10ES10 was Not Met: The Soil Moisture Active and Passive (SMAP) mission PDR is currently scheduled for March 2011, consistent with the schedule presented at the mission's Initial Confirmation Review.	
	FY 2010 Performance Improvement Plan: Currently, all pre-cursor events (i.e., peer reviews, sub-system PDRs) are proceeding on or ahead of plan. However, a launch vehicle has not yet been selected for SMAP, and this could impact the scheduling of the PDR. NASA is addressing this issue, but it is not expected to be resolved until after March.	
Plan Update: The Preliminary Design Review for the SMAP mission occurred in October 2011.		
Fiscal Year 2011 Performance Improvement	ES-11-10 (Performance Goal 2.1.4.2)	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Complete the Soil Moisture Active-Passive (SMAP) Confirmation Review.	FY 2011 Yellow
	Why Measure ES-11-10 was Not Met: The SMAP Confirmation Review was delayed to FY 2012 because of difficulties in identifying an acceptable launch vehicle for the mission. NASA's Earth Science program has been impacted by the current limited availability of launch vehicles in the medium size range that is appropriate for most of its missions.	
	FY 2011 Performance Improvement Plan: The SMAP Confirmation Review has been rescheduled until the second quarter of FY 2012. The Science Mission Directorate (SMD) plans to conduct a Directorate-level Program Management Council (DPMC) review in November 2011 to assess project status and establish near-term observatory development guidelines and constraints following the recent Preliminary Design Review. To conduct the PDR, SMD management requested the project assume use of a Minotaur IV+ launch vehicle. This DPMC will also assess a plan to establish a project baseline cost and schedule, that is independent of a confirmed launch vehicle (which is not expected until mid 2012). This plan forward will consider analysis of observatory design, cost and schedule risks, and any additional required reviews. In parallel with these activities, SMD will continue to work with the Human Exploration and Operations Directorate to pursue launch vehicle options for SMAP.	

Funding Instability		
Fiscal Year 2011 Performance Improvement	ES-11-14 (Performance Goal 2.1.5.3)	
	Accountable Organization: Science Mission Directorate, Earth Science Division	
	Complete the ICESat-2 Spacecraft System Requirements Review.	
	Why Measure ES-11-14 was Not Met: The date for the ICESat-2 Spacecraft Systems Requirements Review has been delayed to December 2011. This review was rescheduled from March 2011 to revisit the mission design and requirements to align with the estimated available budget, moving forward.	
	FY 2011 Performance Improvement Plan: The mission design and requirements have been revised to align to the available funds. As part of the realignment, the mission is moving forward based on a co-manifested launch solution, with shared launch costs, with the Air Force. The Spacecraft System Requirements Review is scheduled for December 2011. The mission's baseline plan is to be manifested with the Defense Meteorological Satellite Program Flight-20 (DMSP F-20) on an Atlas V launch vehicle that has already been purchased by the U.S. Air Force (USAF). NASA will be responsible for funding the Dual Spacecraft System (DSS) development and flight unit qualification. The DSS will represent a new capability for U.S. government payloads using the EELV launch system. The USAF will procure the launch service and provide overall mission assurance related to the launch vehicle and dual payload accommodation. This interagency arrangement provides significant cost savings for NASA, allowing the mission to proceed within its allocated budget.	
		FY 2011 Yellow

Program Planning and Controls		
Fiscal Year 2010 Performance Improvement	10IT06	
	Accountable Organization: Office of the Chief Information Officer	
	Complete Operational Readiness Review (ORR) for the NASA Security Operations Center.	
	Why Measure 10IT06 was Not Met: The Security Operations Center (SOC) Implementation Project was scheduled to have the ORR this year, but has undergone schedule slips due to delays in facilities power modifications and further delays in receiving IT Security data from numerous sources across the Agency. These delays have negated the ability to complete the testing required in preparation of the Operational Readiness Review.	
	FY 2010 Performance Improvement Plan: The SOC Implementation Project will move forward with IT Security event data collection in fall 2010. As the data is obtained, the project will complete final system integration and validation testing. Upon completing validation testing and user training the project will precede to ORR currently scheduled for November FY 2011.	
	Plan Update: The SOC ORR was completed March 2011.	
		FY 2010 Red
Fiscal Year 2010 Performance Improvement	10SFS07	
	Accountable Organization: Space Operations Mission Directorate, Space and Flight Support	
	Complete TDRS K/L Project Mission Operations Review (MOR).	
	Why Measure 10SFS07 was Not Met: The TDRS project had originally scheduled the K/L MOR for September 2010 but was delayed to resolve minor conflicts involving resources.	
	FY 2010 Performance Improvement Plan: The MOR will be held in November 2010.	
	Plan Update: The Mission Operations Review was held in November 2010.	
		FY 2010 Yellow
Fiscal Year 2010 Performance Improvement	10PS06	
	Accountable Organization: Science Mission Directorate, Planetary Science Division	
	Develop missions in support of this Outcome, as demonstrated by completing the Mars Science Laboratory (MSL) flight hardware builds and flight system assemblies.	
	Why Measure 10PS06 was Not Met: The flight hardware build and flight system assembly of the Sample Analysis at Mars (SAM) instrument were not completed during the designated fiscal year, due to complications in the development of the Wide Range Pump (WRP) components of the instrument. The materials originally specified as the primary component of a high-speed, high-performance bearing proved to be inadequate to provide the necessary performance on the surface of Mars, and alternative bearing materials and components had to be researched and developed.	
	FY 2010 Performance Improvement Plan: The development of the new bearing designs has been completed and implemented, and the finalization of the flight hardware build has resumed. The final flight units are on schedule to be delivered in early December 2010.	
	Plan Update: The work was completed by redesigning the primary bearings on the pump from alternate materials that provided the required performance for the Mars environment. Design, fabrication, testing, validation, and installation of the new bearings was completed according to the revised schedule. The pump was completed and delivered to the flight project as scheduled in December 2010.	
		FY 2010 Yellow

Fiscal Year 2011 Performance Improvement	Performance Goal 2.4.2.2	
	Accountable Organization: Science Mission Directorate, James Webb Space Telescope Program	
	Design and assemble James Webb Space Telescope (JWST).	
	<p>Why Performance Goal 2.4.2.2 was Not Met: The measure was placed in the FY 2012 Congressional Justification prior to the project's replan. Based on this, the baseline assumption for the measure was that the project was still operating under the original baseline. The new estimated baseline, which was approved late in the fiscal year, resulted in a 78% increase in the estimated life cycle cost from the original baseline. The new estimated baseline has been endorsed by the NASA Administrator, all reporting required by Section 103 of the NASA Authorization Act of 2005 has been completed, and 95% of the FY 2011 planned activities were accomplished, indicating that it is likely to stay on track for the new estimated cost. Specifically, JWST achieved 19 of its 21 planned FY 2011 milestones on or ahead of schedule, one milestone was achieved one month late and one milestone was delayed due to design changes, and is on track to achieve its FY 2012 milestones. The one planned FY 2011 milestone that was achieved a month late and the one that has been delayed do not impact the critical path.</p> <p>FY 2011 Performance Improvement Plan: NASA has taken many steps to address the challenges seen on the JWST Project. In FY 2010, an independent panel concluded that the problems causing cost growth and schedule delays on the JWST project were associated with cost estimation and program management. To address these, NASA made several important changes in JWST program and project management and in the interaction with the prime contractor. All the JWST senior management at both Headquarters and at Goddard Space Flight Center have been replaced. The program has been taken out of the Astrophysics Division and now reports programmatically to the NASA Associate Administrator, and is an Agency priority. NASA also embarked on revising the cost and schedule estimates. The replanning activity is complete, has been approved within the Agency. The Agency will continue to monitor the progress on the development of this project, as highlighted above.</p>	
Acquisition Management Challenges		
Fiscal Year 2010 Performance Improvement	10SFS08	
	Accountable Organization: Space Operations Mission Directorate, Space Communications and Navigation	
	Complete SN Ground Segment Sustainment project (SGSS) Mission Definition Review.	
	<p>Why Measure 10SFS08 was Not Met: The SGSS Mission Definition Review did not occur as planned due to an ongoing contractor protest.</p> <p>FY 2010 Performance Improvement Plan: NASA will develop a new plan and schedule for completing the Mission Definition Review once the protest is adjudicated.</p> <p>Plan Update: The SGSS contract award was upheld in FY 2011. After the contract was initiated, it was determined that dividing the Mission Definition Review into two parts, with the first part focused on the technical review, and the second part focused on budget, was the appropriate approach. The technical review, which was very successful, was held in July 2011; the second review is scheduled to be held in December 2011.</p>	
Fiscal Year 2010 Performance Improvement	10PS05	
	Accountable Organization: Science Mission Directorate, Planetary Science Division	
	Develop missions in support of this Outcome, as demonstrated by selecting concept studies for the Discovery 12 mission.	
	<p>Why Measure 10PS05 was Not Met: The acquisition timeline for the Discovery 12 mission was extended due to the complexity of the Announcement of Opportunity, which includes the potential use of radioisotope power systems.</p> <p>FY 2010 Performance Improvement Plan: Twenty-eight proposals have been received. Selection of concept studies is scheduled for mid-FY 2011.</p> <p>Plan Update: In May 2011, NASA selected three mission concepts (GEMS, TiME, and Comet Hopper) for study from the 28 proposals received. After a detailed review of the three concept studies in 2012, one will be selected as the 12th Discovery Program mission.</p>	

Fiscal Year 2011 Performance Improvement	AMO-11-12 (Performance Goal 5.2.2.1)	
	Accountable Organization: Office of the Chief Information Officer	
	Achieve Initial Operating Capability (IOC) for five Service Offices (Web Services, Communications, Enterprise Service Desk, End User Services, and NASA Enterprise Applications) as part of the NASA Information Technology Infrastructure Integration Program (I3P).	FY 2011 Yellow
	Why Measure AMO-11-12 was Not Met: Four of the five planned service offices achieved Initial Operating Capability (IOC). The End User Services (ACES), Enterprise Applications (EAST), Enterprise Service Desk (ESD), and Communications (NICS–Networking) services all have their office structures in place, are managing the transition to these new services, and continue to operate the current services. The one service office that did not reach IOC in FY 2011 is the one for the Web services (WEST). The implementation of this initiative has been delayed to resolve some issues with the contract award. NASA remains on track for the consolidation and centralization of these services and capabilities by 2014.	
	FY 2011 Performance Improvement Plan: NASA will continue to work through the issues with the contract award of the web services capability. The implementation of the WEST will be revisited once these issues are resolved.	

Additional Context

Performance Measure ES-11-2: *Complete the Aquarius Launch Readiness Review* is rated Green. The Launch Readiness Review was completed on June 7, and Aquarius was successfully launched on June 10, 2011.

Performance Measure JWST-11-1: *Complete new James Webb Space Telescope (JWST) mission re-baseline* is rated Green. The JWST project completed its rebaseline in September, and information on the new estimated cost and schedule, has been provided to both the Congress and OMB.

Workforce, Workplace, and Diversity

NASA values its workforce and strives to improve its productive environment. The ultimate goal is to ensure the workplace allows employees from diverse backgrounds, ethnicities, and genders to reach their potential and contribute to NASA's mission. Multiple offices work together, to this end, including the Office of Human Capital Management, the Office of Diversity and Equal Opportunity, and the Office of Education. The latter office contributes to developing a national science, technology, engineering, and mathematics (STEM) workforce, one that NASA can draw upon to meet its hiring needs.

The performance measures below demonstrate NASA's efforts to continually improve the workforce environment, for all employees through multiple initiatives, and to influence a STEM pipeline, with diverse populations to draw upon for hiring needs. Multiple factors can impact these efforts, including funding delays, imperfect data collection methods, and receiving changes to priorities mid-year from the Administration or Congress. In the case of several of these measures, NASA performance is trending well, but the original targets were aggressive, which is demonstrated by the rating.

Continual Improvement of the Workforce Environment		
Fiscal Year 2011 Performance Improvement	AMO-11-6 (Performance Goal 5.1.1.4)	
	Accountable Organization: Mission Support Directorate, Office of Human Capital Management	
	Identify and address at least two topics that employees identified in the latest Federal Employee Viewpoint Survey.	
	<p>Why Measure AMO-11-6 was Not Met: This annual performance goal was not met. Many of the planned activities were completed but several have been delayed into FY 2012. Specifically, the identified areas to be addressed, and their corresponding action plan, are as follows:</p> <p>1) Continue focus on teamwork/working together to ensure mission success. Planned actions included continual monitoring of Shuttle workforce concerns through regular surveys; and instituting a team-building focus in Agency leader development programs. The activities toward this topic were completed in this fiscal year.</p> <p>2) Ensure that recognition and rewarding of employees is fair, consistent, and based on results-oriented performance. The planned actions included educating and training supervisors, through Agency supervisory training courses; and implementing recommendations for enhancing the Agency's Honor Awards Program. Both of these planned actions were delayed into FY 2012. This year's funding level removed the option for conducting further Agency supervisory courses in FY 2011. Additionally, the development of new policies surrounding the Agency Honor Awards Program, is taking more time than planned, resulting in a delay until FY 2012.</p> <p>FY 2011 Performance Improvement Plan: These actions will be completed in fiscal year 2012. OHCM will continue focus on teamwork and working together to ensure mission success. Actions include continual monitoring of Shuttle workforce concerns through regular surveys; and team-building focus in Agency leader development programs. OHCM will also ensure that recognition and rewarding of employees is fair, consistent, and based on results-oriented performance. Actions include educating and training supervisors through Agency supervisory training course and to implement recommendations for enhancing the Agency's Honor Awards Program.</p>	FY 2011 Yellow
Fiscal Year 2011 Performance Improvement	AMO-11-7 (Performance Goal 5.1.1.5)	
	Accountable Organization: Office of Diversity and Equal Opportunity	
	Complete FY 2011 actions described in the NASA Model Equal Employment Opportunity (EEO) Agency Plan.	
	<p>Why Measure AMO-11-7 was Not Met: NASA made significant progress on many of 57 activities, contained in the Model EEO Agency Plan for FY 2011-2013, which have efforts in fiscal year 2011, but did not complete all the planned actions. NASA sought to complete 40 of the 57 actions in the first year of the Plan alone. NASA completed 14 of these actions (35 percent). In addition, NASA completed five actions not targeted for completion until FY 2012. Of the other actions targeted for completion in FY 2011, NASA has partially completed 19 (48 percent). NASA has completed key actions related to the Agency's Anti-Harassment Program, Conflict Management Program, and the Functional Review Program is on track for completion of its actions. However, as a result of recent Executive Orders that required development of action plans in FY 2010-2011 for Asian Americans and Pacific Islanders, Individuals with Disabilities, and Veterans, NASA had to add multiple actions to the Model EEO Agency Plan. The initial development of these plans, dispositioning of community group comments, and introduction of approximately 20 new actions, mid-year, did not allow time for full progress to be made. All efforts continue to progress, and are expected for completion before the end of the plan's timeframe.</p> <p>FY 2011 Performance Improvement Plan: NASA is committed to continuing the efforts to remove barriers to a diverse and inclusive workplace, conducive to employees reaching their potential. In order to fully meet the objectives of the Plan, in FY 2012, NASA will: 1) undertake a careful review of the remaining actions and their target dates, taking into account new information, such as recent Government-wide initiatives relating to EEO and diversity; and 2) revise the Plan accordingly.</p>	FY 2011 Yellow

An Inclusive and Diverse STEM Workforce		
Fiscal Year 2010 Performance Improvement	10ED03	
	Accountable Organization: Office of Education	
	Serve 8,500 under-represented and under-served students in NASA higher education programs.	
	<p>Why Measure 10ED03 was Not Met: In FY 2009, 6,743 higher education students self-reported as being part of an underserved and underrepresented race or ethnicity. This represents 40.6 percent of the total number of higher education students served by NASA in FY 2009, an increase from 28 percent of all higher education students similarly reporting in FY 2008. Of all higher education students served by the Agency, 43 percent self-reported being women, an increase from 41 percent in FY 2008. These figures are well above national averages for participation of minority students according to the National Science Foundation's report, Women, Minorities, and Persons with Disabilities in Science and Engineering, released in April 2010. The reduction in the number of minority higher education students served (6,743 students rather than the goal of 8,500) also reflects an increased emphasis on institutional awards for education and research, and a corresponding decrease in individual student awards. The overall reduction in direct support to all higher education students in turn affects the total number of higher education underserved and underrepresented students reached by NASA. In FY 2007, the total number of higher education students reached was 34,493; in FY 2008, the number dropped to 24,362, in FY 2009, it dropped further to 24,168. Higher education projects are adjusting to address this trend, but there is significant lag time before results are available (e.g., new course development time, time to execute activities, grant reporting lag time). Another factor adversely influencing the number of individual student awards is the increasing cost of education. To offer individual awards that remain competitive with those of other federal programs and industry, NASA grantees must increase award amounts that meet cost increases in tuition, travel, and other expenses. In a flat or reduced budget environment, an increase in award size means that fewer direct support awards can be made.</p>	FY 2010 Yellow
	<p>FY 2010 Performance Improvement Plan: NASA higher education projects are actively working to increase the participation of underrepresented and underserved students. Future efforts include plans to work more closely with community colleges and institutions that tend to serve large numbers of underserved students. The Space Grant Program, which works with affiliates in all 50 states, the District of Columbia, and Puerto Rico, has actively encouraged state consortia to better engage minority-serving institutions in their networks. The consortia are accountable for improving the participation of underserved students in their programs, determined as a percentage of their audience base. The strategy has been successful, as participation of racially and ethnically underserved and underrepresented students in the Space Grant Program has increased from 15 percent in FY 2007, to 21 percent in FY 2008, and to 29 percent in FY 2009.</p>	
	<p>Plan Update: The performance improvement plan was successful, and NASA was able to work more closely with community colleges in FY 2010. In doing so, NASA increased its overall reach to underrepresented and underserved populations. However, the number of underrepresented and underserved students reported for FY 2010 does not reflect the increases seen in previous years, due to the availability of data associated with Space Grant activities. NASA released a supplemental competition, not in the first round of competitions, to the Space Grant Consortia to assist in strengthening linkages with Minority Serving Institutions, but this data will not be available until the end of the 2011 calendar year. The competition was released in late FY 2010 due to ongoing continuing resolutions which delayed funds. As a result, the currently available FY 2010 results only reflect underrepresented and underserved participation resulting from the standard Space Grant awards. The additional Space Grant awards, are expected to yield additional underrepresented and underserved participants, but will not be available until the grant performance period has concluded and grant reporting is completed.</p>	

Fiscal Year 2011 Performance Improvement	ED-11-1 (Performance Goal 5.1.2.1)	
	Accountable Organization: Office of Education	
	Achieve 40 percent participation of underserved and underrepresented (in race and/or ethnicity) in NASA higher education projects.	FY 2011 Yellow
	Why Measure ED-11-1 was Not Met: This annual performance goal was not met. Out of the 15,947 participants in NASA higher education programs who self-reported their race and ethnicity, 35 percent, reported being a member of an underserved or underrepresented race or ethnic group. NASA's aggressive goal of 40 percent, exceeds the national averages for underserved and underrepresented participation in higher education, and was a challenge that the Agency chose to undertake. The participation in NASA's programs did meet or exceed the percentages of underrepresented minorities pursuing higher education studies in STEM fields nationwide (between 11 to 21 percent of these degrees, at the bachelor level, according to the National Science Foundation Report, Women, Minorities and Persons with Disabilities in Science and Engineering: 2011).	
FY 2011 Performance Improvement Plan: The cultivation of diversity is a core value for all NASA education efforts, and NASA will challenge itself to continually improve. The performance improvement plan, that addressed the last fiscal year's performance, was successful in that NASA was able to work more closely with community colleges in FY 2010, which reflected in increases seen in FY 2011 measures. In doing so, NASA increased its overall reach to underrepresented and underserved populations, moving from one year to the next. NASA has refocused several projects within the Agency's higher education portfolio during FY 2011 in pursuit of this goal, including the announcement of two new grant opportunities targeted at minority serving institutions and community colleges, which tend to have larger populations of underserved and underrepresented students. In FY 2012, NASA will seek to improve the percentage of underrepresented and underserved students, that participate in its higher education programs by placing increased emphasis on inclusion and participation by these populations in the projects that reach the largest numbers of undergraduate and graduate students, such as the Space Grant Project. Additionally, NASA plans to take a more holistic look, across the Agency, where activities in the mission organizations, may be encouraging participation, and factor in this data for a more complete picture.		
Fiscal Year 2011 Performance Improvement	ED-11-2 (Performance Goal 5.1.2.1)	
	Accountable Organization: Office of Education	
	Achieve 45 percent participation of women in NASA higher education projects.	FY 2011 Yellow
	Why Measure ED-11-2 was Not Met: This annual performance goal was not met. Out of the 15,568 participants in NASA higher education programs who self-reported their gender, 39 percent, reported being female. Albeit a greater number of women currently pursue higher education studies in the United States, men pursue a higher proportion of the degrees in science and engineering fields. For example, compared with men, women earn degrees at medium to low levels in physical sciences and mathematics (between 30 to 44% of these degrees), and at low levels in computer science and engineering (between 18 to 27% of these degrees). Despite the statistics, NASA still chose to set an aggressive goal of 45 percent, and fell just short of the challenge.	
	FY 2011 Performance Improvement Plan: In FY 2012, NASA will seek to improve the percentage of women that participate in its higher education programs by placing increased emphasis on inclusion and participation by these populations in the projects that reach the largest numbers of undergraduate and graduate students, such as the Space Grant Project. NASA currently conducts a significant number of K-12 and informal STEM education projects that specifically target participation by pre-college girls. By stimulating interest in STEM among young females in the Agency's education pipeline, NASA expects that many of these students will remain engaged and continue to participate in NASA programs upon entering college.	
Additionally, NASA plans to take a more holistic look, across the Agency, where activities in the mission organizations, may be encouraging participation, and factor in this data for a more complete picture.		

Fiscal Year 2010 Performance Improvement	10ED04	FY 2010 Yellow
	Accountable Organization: Office of Education	
	Achieve 60% employment of student participants in FY 2009 NASA higher education programs by NASA, aerospace contractors, universities, and other educational institutions.	
	Why Measure 10ED04 was Not Met: In FY 2010, NASA's education workforce development target was 60 percent of students from NASA's higher education programs entering into NASA-related careers. Of the 1,343 students who self-reported employment data, 625 students (or 46.5 percent) reported working for NASA, aerospace contractors, universities, or other educational institutions. One project, Motivating Undergraduates in Science and Technology (MUST) was used as a prototype for more closely mapping an Office of Education project directly to the NASA Early Career Hiring Initiative. This collaborative approach succeeded in placing 22 of 29 graduates with NASA and JPL. The overall drop in employment rate in these specific sectors, relative to previous years, may be a result of uncertainty in NASA's plans (e.g., retirement of Space Shuttle Program, future of the Constellation Program), and overall poor health of the U.S. economy in 2008/2009. However, 38.6 percent of graduates (in addition to those hired by NASA, aerospace industry and educational organizations), chose STEM-related careers. One might conclude that NASA in-depth education experiences are indicative of STEM workforce preparation.	
	FY 2010 Performance Improvement Plan: NASA organizations with a stake in developing the future workforce will continue to work collaboratively with each other and industry partners to identify future workforce trends and needs. New efforts in the One Stop Shopping Initiative include closer collaboration between NASA's hiring managers and mentors for higher education students.	
	Plan Update: The performance plan was successful. In the year following, of the graduates who participated in NASA Higher education programs and self-reported employment data, 60.3 percent reported working for NASA, aerospace contractors, universities, or other educational institutions. NASA organizations have worked collaboratively with each other, as well as industry partners, to meet their respective workforce needs. Additionally, closer collaboration between NASA's hiring managers and mentors for higher education students have yielded positive results.	

Additional Context

Performance Goal 5.1.1.3: *Achieve and sustain an effective labor-management dialogue* is rated Green.

Performance Measure AMO-11-5: *Identify and address at least three significant labor-management challenges identified during the year during periodic Agency-led Labor Management Forums* is rated Green. This annual performance goal was exceeded as four Labor Management Forums were held on FY 2011. Discussions in these forums addressed usage of term appointment authority, a review of the Agency performance management process with a focus on "level 2" ratings to address concerns about discrimination, and a discussion of line management/program management communication issues.

Performance Goal 5.1.1.6: *Implement an Agency-wide Diversity and Inclusion Framework to develop a more demographically diverse workforce and a more inclusive work environment* is rated Green.

Performance Measure AMO-11-8: *Establish a baseline for diversity by developing and implementing an Agency-wide diversity-inclusion survey* is rated Green. NASA deployed its Diversity and Inclusion (D&I) Assessment Survey in early FY 2010, which was responded to by 40 percent of the workforce. The results of the survey have been completed and disseminated to the Agency's D&I leads and other stakeholders, who continue to use this data to inform the development of NASA's D&I Strategic Plans.

Performance Goal 5.1.1.1: *Define and build the workforce skills and competencies needed for the Agency's future directions in technology development and deep space exploration* is rated Green.

Performance Measure AMO-11-2: *Twenty percent or more of annual recruitments will be through the early career hiring initiatives* is rated Green. This annual performance goal was met, as 20 percent of total hires in FY 2011, are considered "early career".